NITRIFICATION STUDY

WAUKEGAN MANUFACTURED GAS AND COKE PLANT (WCP)
WAUKEGAN, ILLINOIS

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EXECUTIVE SUMMARY

Groundwater at the Waukegan Manufactured Gas and Coke Plant Site in Waukegan Illinois requires treatment to reduce the concentrations of arsenic, ammonia, phenols, and several other chemical compounds. Treated groundwater will be reinjected into the ground.

A groundwater Pilot Project Study was completed in 2000 and 2001 (final Pilot Project Report, July 2001 (CRA). Potential groundwater treatment technology was evaluated during the Pilot Project Study. It was determined that Fenton's reagent treatment (a mixture of ferrous sulfate and hydrogen peroxide) can be successfully applied to remove up to 90 percent of the arsenic while simultaneously removing up to 15 percent of other organic contaminants and thiocyanate. Biological treatment in Sequencing Batch Reactors (SBR's) removed up to 99 percent of phenols, >95 percent thiocyanate, and >90 percent of all specific organic compounds. Nitrification of ammonia was clearly established in the SBR's but complete and consistent nitrification was not achieved during the groundwater Pilot Project Study. As a result, a follow-up Nitrification Study was undertaken as presented in this report.

The main objective of the Nitrification Study was to demonstrate that SBR's could successfully achieve complete and consistent nitrification of representative groundwater which has high concentrations of ammonia, TKN, thiocyanate, arsenic, and phenol. Specific objectives are to:

i) validate the efficacy of the pre-treatment procedure for arsenic removal developed during the "Pilot Project";

ii) acclimatize sludge in a sequencing batch reactor to achieve complete nitrification (i.e., effluent ammonia concentration of <1 mg/L) as well as greater than 80% removal of organics and phenols;

iii) determine if arsenic pre-treatment is required to achieve stable and complete nitrification;

iv) determine the fate of arsenic during biological treatment;

v) evaluate arsenic treatment options during biological treatment or after treatment to meet ROD objectives; and

vi) establish a design basis for the preferred treatment system.

Groundwater from the Waukegan Manufactured Gas and Coke Plant Site was blended to create sample water that was considered to be representative of groundwater quality to be treated. The target for ammonia was 450 to 500 mg/L and for arsenic 2.7 to 7.5 mg/L. Part of the blended sample water was subjected to pretreatment testing to confirm the appropriate dose of Fenton's reagent and humates. Pretreatment was conducted to reduce arsenic concentrations in case the arsenic concentrations were inhibitory to the nitrifying micro-organisms.

Two SBRs were operated in parallel. SBR1 was fed raw groundwater while SBR2 was fed pretreated groundwater. The SBRs were initially seeded with sludge from a coke wastewater plant at DOFASCO in Hamilton, Ontario. Acclimatization with this sludge service was considered to be too slow and the process was re-started with sludge from the Clairton Coke Works in Pittsburgh, Pennsylvania.

Acclimatization took longer than expected but after two months a robust consortia of micro-organisms was established and operated in a steady state condition at 7.5 days HRT and 100 days SRT at 30°C. All treatment objectives were met without difference between pre-treated feed and raw feed with respect to organic removal and nitrification.

After establishing consistent performance several optimization experiments were conducted:

- The HRT was reduced to 5 days and then 3 days while still achieving effluent discharge criteria of <1 mg/L NH_3-N.
- The temperature was reduced first to 25°C and then to 19°C while still achieving effluent discharge criteria.
- The feed cycle was reduced from six to three cycles per day.
- Two reactor upsets were intentionally initiated by different causes (aeration failure and pH control failure) so that recovery procedures could be developed and tested. It was determined that an acclimatized biomass can be recovered (effluent ammonia <1 mg/L) from a complete nitrification upset in approximately 3 days. Full recovery of pre-upset biokinetic conditions may take up to 9 days. Recovery steps consist of neutralizing the pH, warming the biomass to 30°C, sludge washing and seeding the upset reactor from a normally operating reactor.
- It was determined that arsenic up to 10 mg/L was not affecting nitrification and consequently both operating reactors were switched to raw groundwater feed. Several strategies to address arsenic were then evaluated. Ferric Chloride was added directly to the mixed liquor in the reactors. This strategy eventually led to

low arsenic concentrations in the effluent but the resulting biomass sludge after washing and air drying is RCRA characteristic hazardous for arsenic.

Tertiary treatment to remove arsenic from the effluent was also evaluated using:

- ferric chloride;
- ferrous sulfate;
- ferrous sulfate and humates;
- Fenton's reagent and humates at pH = 7.4;
- Fenton's reagent at pH = 3.5; and
- activated alumina adsorption.

Fenton's reagent treatment produced the best quality effluent but was not significantly better than the effluent produced by adding ferric chloride directly to the SBR.

In summary, the conclusions of the Nitrification Study are:

a. Pretreatment for arsenic is not required to achieve complete and consistent nitrification;

b. Biological treatment is effective in reducing the concentration of target chemicals;

c. The SBR system can rapidly recover (i.e., 3 days or less) from upset conditions using the recovery procedure developed in this study;

d. Reducing arsenic concentrations requires chemical treatment;

e. Sludges from the treatment system are likely to be RCRA characteristic hazardous for arsenic; and

f. The design basis for the preferred treatment system is:
   - one equalization tank (HRT ≅ 1 day),
   - three covered SBR's (HRT = 5 days),
   - air pumped from covered SBRs and treated to control odor and possibly arsenic,
   - effluent equalization tank,
   - sludge storage tank,
   - filter press,
   - filtrate returned to influent, and

- pressed sludge a RCRA characteristic hazardous waste.

g. The expected operating strategy will include 3 feeding cycles per day consisting of:

- 60 minutes FILL,
- 260 minutes REACT,
- 100 minutes SETTLE, and
- 60 minutes DRAW.

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1.0 INTRODUCTION

This report presents the methodology and results of a "Nitrification Study" conducted on groundwater obtained from the Waukegan Manufactured Gas and Coke Plant (WCP) Site located in Waukegan, Illinois (Site). The Nitrification Study follows and builds on a previous treatability study conducted on groundwater from the WCP Site. The previous treatability study is presented in the Pilot Project Report, Waukegan Manufactured Gas and Coke Plant, July 2001.

The Pilot Project Report identified that "nitrification is the process that will determine design kinetics and full scale design parameters". The Pilot Project Report recommended that a follow up bench-scale system be operated to confirm that nitrification could be reliably used to treat the WCP Site groundwater. The Nitrification Study presented in this report is the follow up study that was recommended in the Pilot Project Report.

Like the Pilot Project Treatability Study this Nitrification Study has two primary treatment components: Pretreatment for arsenic; and Biological Nitrification for ammonia treatment.

1.1 SITE OVERVIEW

The WCP Site occupies 36 acres in Waukegan, Illinois, on a peninsula separating Waukegan Harbor on the west from Lake Michigan on the east (Figure 1.1). The property and its environs are part of the industrial/commercial waterfront in Waukegan. The sand dunes and beach area adjacent to the WCP Site are used for public recreation. Figure 1.2 provides a plan view of the Site.

The Site is underlain by near-surface fill materials that were placed over a fine-grained sand unit. The sand unit extends from the ground surface or the near surface fill materials to the top of a low-permeability clayey till unit present at approximately 30 feet below ground surface. Shallow groundwater occurs in the fine-grained sand unit. Shallow groundwater flows in response to infiltration on the peninsula, discharging to the surrounding surface water. The vadose zone soil and the shallow aquifer at the Site have been affected by past activities. Soil at the WCP Site contains coal tar and arsenic and is being addressed in the Soil Operable Unit Remedial Action. The groundwater contains arsenic, ammonia, phenols, and several other chemical compounds. The most affected portion of the shallow aquifer is found in the lowest 5 feet of the sand unit, approximately 25 to 30 feet below ground surface.

Barr Engineering conducted a Remedial Investigation/Feasibility Study (RI/FS) at the Site between 1992 and 1998. The U.S. Environmental Protection Agency (USEPA) issued a Record of Decision (ROD) for the Remedial Action at the Site in September 1999. The selected remedy presented in the ROD included soil and groundwater components. A pre-design groundwater pilot project, designed to further evaluate the practicality of extracting, treating and re-injecting groundwater, was completed in March 2001 and submitted to the United States Environmental Protection Agency (USEPA). The Pre-Design Study report is known as the Pilot Project Report. The Pilot Project Report concluded that the concepts and principles underlying cell based groundwater extraction and reinjection were confirmed and that biological nitrification was achieved. However, the parameters required for successful scale up of the biological treatment process were not defined during the Pilot Project and an additional nitrification study, as presented in this report, was required to facilitate treatment system design.

1.2 SUMMARY OF THE PILOT PROJECT TREATABILITY STUDY

The groundwater Pilot Project Study was completed in 2000 and 2001 (final Pilot Project Report, July 2001, CRA).

During the Pilot Project Study potential technology for treating groundwater collected at the Site was evaluated in two parts, pre-treatment for arsenic removal and biological treatment for removal of organic compounds, ammonia and thiocyanate. It was determined that Fenton's reagent treatment (a mixture of ferrous sulfate and hydrogen peroxide) can be successfully applied for removal of arsenic (generally 80 to 90 percent removal). During the same treatment, partial removal (approximately 15 percent) of organic contaminants and thiocyanate was also achieved.

Biological treatment of pre-treated groundwater from the Site applying Sequencing Batch Reactor (SBR) technology removed up to 99 percent of phenols, >95 percent of thiocyanate, and >90 percent of all specific organic compounds.

Nitrification (biological oxidation of ammonia to nitrate) in the SBR system was clearly established achieving up to 60 percent removal ammonia. However, one of the conclusions of the Pilot Project Study was that the test was not planned or configured to operate long enough to fully acclimatize the biomass to a very high concentration of ammonia in the groundwater [NH_3-N up to 2000 mg/L, TKN ~2000 mg/L)]. As a result, complete and consistent nitrification was not achieved.

The Pilot Project Report recommended that a follow up bench scale system be operated to address the following:

a) longer acclimatization and operation period so that stable biological treatment is achieved;

b) parallel operation of biological treatment process with and without arsenic pre-treatment to monitor the fate of the arsenic in the process; and

c) representative influent concentrations as opposed to the start-up concentrations used in the Pilot Project Treatability Study.

1.3 NITRIFICATION STUDY OBJECTIVES

A Nitrification Study Work Plan (NSWP) was included with the "Groundwater Pre-Design Study Work Plan" that was submitted to USEPA in January 2002. Modifications were made to the Work Plan and submitted to the USEPA in September 2002. USEPA comments on the modified Work Plan were addressed in an October 30, 2002 letter to the USEPA.

The purpose of the NSWP was to plan and conduct the long-term operation of a bench-scale system that would define the parameters for successful scale up of a biological groundwater treatment system.

Overall study objectives for this Nitrification Study were defined in the NSWP.

The following detailed objectives incorporate and elaborate on the overall study objectives:

i) validate the efficacy of the pre-treatment procedure for arsenic removal developed during the "Pilot Project";

ii) acclimatize sludge in a sequencing batch reactor to achieve complete nitrification (i.e., effluent ammonia concentration of <1 mg/L) as well as greater than 80% removal of organics and phenols;

iii) determine if arsenic pre-treatment is required to achieve stable and complete nitrification;

iv) determine the fate of arsenic during biological treatment;

v) evaluate arsenic treatment options during biological treatment or after treatment to meet ROD objectives; and

vi) demonstrate effective treatment and operating conditions that can improve the effectiveness or reduce the cost of full-scale treatment: lower hydraulic retention time, lower temperature, and optimize operating strategy.

Treatment process design parameters will be presented in the groundwater Preliminary Design.

The Nitrification Study reports on the following items:

- Collection and characterization of representative groundwater samples that are used to create bulk samples that are representative of expected extraction system water quality;
- Pre-treatment of representative bulk sample groundwater for arsenic removal;
- Acclimatization of activated sludge in an SBR for nitrification using raw and pretreated groundwater
- Optimization of SBR operation for nitrification using raw and pre-treated groundwater;
- Evaluation of upset recovery procedures for the biological treatment system; and
- Evaluation of alternatives to pretreatment for arsenic removal in the biological treatment system.

2.0 GROUNDWATER CHARACTERIZATION

The results of the Pilot Study, summarized in the Pilot Project Report, demonstrated that parameter concentrations declined significantly over the first 10 days of pumping and remained at reduced levels under the various pumping scenarios that were tested during the Pilot Project.

The Pilot Project Report also demonstrated that nitrification is the process that will determine design kinetics and full-scale design parameters. Consequently, ammonia was expected to be the key parameter for determining the treatability of the Site groundwater.

Arsenic is another important parameter of the groundwater that could affect the efficiency of treatment and could have an impact on the full-scale system capital and operational costs. Consequently, ammonia and arsenic were selected to characterize expected representative long-term groundwater quality.

Preliminary modelling results indicated that representative groundwater concentrations for ammonia and arsenic are expected to be, approximately:

NH_3-N = 450 to 500 mg/L

Arsenic = 2.5 to 7.5 mg/L

As a result, these were the target concentrations used to define representative influent groundwater quality for the nitrification study.

Details of representative well selection and groundwater sample shipment, storage and preparation are presented in Appendix A.

Analytical data for groundwater composite batches used as feed in the nitrification study are presented in Table 2.1. Variations in the main parameters of concern are presented on Figure 2.1 (NH_3-N, TKN, thiocyanate); Figure 2.2 (COD, TOC, DOC); Figure 2.3 (TOC, phenols); and Figure 2.4 (arsenic).

As the groundwater to be treated in a full scale system will be originating from different wells with widely varying composition, which will be equalized before treatment, these variations are considered to be acceptable. Success in achieving consistent nitrification during the nitrification study, using feed with this variable composition, will help

ensure that a full scale treatment system , that is based on the study results, will have sufficient flexibility to treat the variable influent water composition.

3.0 BACKGROUND AND OBJECTIVES

3.1 ARSENIC PRE-TREATMENT

Arsenic is a known inhibitor of biological processes. Elevated concentrations of arsenic in the groundwater (6 to 11 mg/L) may inhibit nitrification. The potential for arsenic inhibition was the main reason for evaluating arsenic pre-treatment prior to biological treatment.

During the Pilot Project Treatability Study it was determined that Fenton's reagent treatment (a mixture of ferrous sulfate and hydrogen peroxide) can successfully remove 80-90 percent of arsenic from the site groundwater. It was also discovered that a 1,000 mg/L dose of humates allows this treatment to operate at a neutral pH while Fenton's reagent treatment typically requires pH <3.5.

The composite groundwater feed used during this Nitrification Study contained high concentrations of phenol and other organics. During the pre-treatment, these organic compounds are also oxidized by the hydrogen peroxide in the Fenton's reagent thus requiring a higher dose of Fenton's reagent to achieve the desired arsenic removal. Therefore, additional screening tests with a range of hydrogen peroxide doses were included in this Nitrification Study.

The main objective of the pre-treatment study was to determine the chemical dosage requirements to achieve greater than 80% arsenic removal.

3.2 BIOLOGICAL NITRIFICATION

Many of the constituents found in the site groundwater are potential inhibitors of nitrification. These inhibitors include phenols, thiocyante, and arsenic. The inhibitory effects of these constituents alone and together were evaluated in the Laboratory Biotreatability Study Report to Evaluate Aerobic Bioremediation of Contaminated Site Groundwater, Waukegan Manufactured Gas and Coke Plant Site, Waukegan, Illinois (Fluor Daniel, 1998). The SBR treatability data presented in the Pilot Project Report supported the hypothesis that the organic constituents and thiocyanate were all degraded prior to significant nitrification occurring. This is likely due to their inhibitory affects on nitrification. These inhibitory effects are reduced as these constituents are degraded. The Pilot Project Report concluded that "nitrification is the process that will determine design kinetics and full scale design parameters". This conclusion is consistent with the results of previous treatability work on the WCP groundwater.

The main objective of the Nitrification Study, therefore, was to demonstrate that an SBR (i.e., periodically operated biological treatment system) could successfully achieve complete and consistent nitrification of representative groundwater which has high concentrations of ammonia, TKN, thiocyanate, arsenic, and phenol.

Two SBR's were operated in parallel: SBR1 treating raw groundwater and SBR2 treating groundwater after arsenic removal by pre-treatment. Parallel operation of the two SBRs permitted early evaluation of the potential for arsenic to affect biological treatment of organics, thiocyanate, and ammonia. A third SBR was maintained in a standby condition to provide supplementary biomass, if required.

Specific objectives of each phase of the nitrification study are presented in the following subsections.

3.2.1 ACCLIMATIZATION

The purpose of acclimatization was to enrich those organisms in the biomass that could achieve degradation of organics and thiocyanate as well as nitrify the ammonia at concentrations that are representative of predicted groundwater concentrations from the extraction system. As concluded in earlier studies and supported by the data presented in this report, organic degradation, including phenols and thiocyante will occur before significant nitrification occurs. Therefore, the biomass was considered acclimatized when the ammonia concentration in the effluent was consistently reduced to <1 mg/L for at least one week.

Once the reactors achieved steady nitrification at an HRT of 7.5 days, the SBR's were operated for 4 to 6 weeks with consistent operating conditions. The objective during this period was to collect data that would permit the scale up and design of a full scale system in the event that further optimization of operating parameters was not possible.

3.2.2 OPTIMIZATION OF SBR OPERATION

Further optimization efforts focused on the following parameters:

- HRT: Lowering the operating HRT of the system from 7.5 to 5 days. Subsequent testing looked at further lowering of the HRT to 3 days. The objective was to determine a low HRT that could consistently meet the treatment objectives;

- Reaction Rate: Increasing the reaction rates in the reactor by increasing the organic and ammonia loading rate on the reactor by reducing the time that feed is periodically added to the reactor. The objective was to increase parameter concentrations to achieve high reaction rates to reduce the time required to achieve ammonia concentrations <1 mg/L.;
- Reactor Temperature: Lowering the mixed liquor temperature from 30°C to as low as reasonable while maintaining an ammonia concentration of <1 mg/L at the end of each REACT period. The objective was to determine a reasonable low temperature that could meet treatment objectives; and
- Arsenic Removal: Simplify arsenic removal by precipitating arsenic in the SBR by the addition of ferric chloride. The objective was to determine the effect of precipitating arsenic in the biological sludge on meeting treatment objectives.

3.2.3 UPSET RECOVERY

The goal of this study was to develop the basis for the design of a full scale treatment system that would treat groundwater extracted from the WCP site. As stated above, nitrification was the limiting reaction in the treatment of the groundwater. Due to the potential inhibition of various components in the groundwater to nitrification and experience treating similar coke plant wastewater, it was considered advantageous to develop upset recovery procedures as part of this test.

Two reactor upsets were intentionally initiated by different causes (pH control failure and aeration failure) so that recovery procedures could be developed and tested. The objective of these tests was to validate the efficacy of an upset recovery procedure.

3.3 TERTIARY ARSENIC TREATMENT

With the discovery that pre-treatment of groundwater for arsenic was not required to achieve complete and consistent nitrification, tertiary treatment of arsenic became an option for meeting arsenic removal objectives. Various chemical precipitation and absorption methods were evaluated for removal of arsenic from biologically treated groundwater. The objective of this portion of the study was to evaluate several options for post-biological treatment arsenic removal so that the most cost effective means of arsenic removal could be determined during system design.

4.0 PROCEDURES

4.1 ARSENIC PRETREATMENT

The following procedure was used to evaluate the removal of arsenic from raw groundwater:

1. 1 litre of composite sample was mixed with 1,000 mg of humates (MICROHUMATE, Mesa Verde Resources, Rio Rancho, NM). Then 60 mg of ferric sulfate was added during vigorous mixing. Finally, 30 mg (Test 1), 40 mg (Test 2) or 50 mg (Test 3) of hydrogen peroxide was added and the mixture was stirred for another 60 minutes; and
2. treated samples were analysed for TSS, arsenic, phenols, COD, TOC, cyanide and thiocyanate. Each test was conducted in triplicate and the results were averaged.

After determining the appropriate dose of humates and Fenton's reagent the pre-treatment of the groundwater composite batches was conducted at a frequency sufficient to provide a steady supply of influent to the SBR's throughout the study. An excess of the pre-treated water was kept at 5°C in closed containers. As the supply of pre-treated water was depleted, freshly pre-treated water was added to the same containers to maintain a supply pre-treatment groundwater for the biological system in SBR2.

4.2 *BIOLOGICAL NITRIFICATION OF GROUNDWATER*

4.2.1 SEQUENCING BATCH REACTORS (SBR)

The treatment system used in this study consisted of two working reactors (SBR1 and SBR2) and one back-up reactor (SBR3). The SBR is an activated sludge, periodic process used for the biological treatment of water and wastewater. Reactor based periodic systems provide for the time sequencing of two or more processes or operations (e.g., equalization, biological transformations, and clarification) during a complete reactor cycle. Each cycle may include up to four periods (i.e., FILL, REACT, SETTLE, and DRAW).

During FILL, wastewater enters a partially filled tank containing acclimated biomass. Aerobic or anaerobic reactions can be initiated during FILL by providing either aeration or only mixing. Fill continues until the tank reaches its predetermined operating liquid level. The reactions initiated during FILL are continued during REACT. The time set

aside for REACT must be sufficient to allow the desired effluent requirements to be met. After REACT, the biomass is allowed to SETTLE quiescently for a predetermined period of time by shutting down the mixing and aeration equipment. The treated, clarified effluent is then removed during DRAW.

A schematic of the reactor setup is presented on Figure 4.1. Photographs of the reactors with all associated equipment and controls are presented in Appendix B.

4.2.2 SBR CONTROLS AND MONITORING

Each working reactor (SBR1 and SBR2) was equipped with a mixer, an aeration system, a heater and a pH probe connected to a pH controller. Each reactor had a dedicated influent and effluent tank and separate peristaltic pumps for influent supply and effluent collection. All operations of peristaltic pumps, the mixer and aerators were controlled by timers.

Reactor SBR2 was also equipped with a copper coil connected to a potable water supply during the later stages of the study. This arrangement permitted gradual decreasing of the reactor temperature to levels lower than ambient laboratory temperatures.

The back up reactor (SBR3) was equipped with an aeration system to maintain a concentration of dissolved oxygen >5 mg/L. The aeration system also provided mixing of the reactor contents.

All three reactors had a working volume of 15 litres, which was maintained during the entire study. Any loses of water due to evaporation were compensated by the addition of aerated potable water.

Initially, the pH of the working reactors was monitored manually and adjusted with the addition of 5 percent soda ash (Na_2CO_3) solution. Later SBR1 and SBR2 were equipped with pH controllers (Cole-Parmer, Model 5625) that also used 5 percent soda ash solution for pH adjustment.

Due to the high concentration of solids in the reactors the pH electrodes connected to the controllers were cleaned every day and calibrated using standard pH solutions.

pH controller operation was checked manually, at least 3 times a day with a laboratory pH meter (ThermoOrion Model 58804). When significant differences (>0.5) between the

pH meter and controller were found the controller electrode was removed, cleaned and recalibrated.

Dissolved oxygen concentration (DO) was monitored manually, at least two times a day with a YSI Model 55 DO meter. After March 17, 2003, the DO was monitored at least three times a day. The meter was calibrated daily against the air concentration of oxygen and calibrated with aqueous standards every month. The DO concentration in the reactors was maintained >2.0 mg/L. When lower concentrations were observed (particularly during feed cycle) additional air pumps were connected.

The ammonia concentration in all three reactors was monitored using an ammonia/ammonium selective electrode (ThermoOrion). The electrode was calibrated daily using standard ammonia solutions.

Initially, samples of mixed liquor from the reactors were also collected and sent to an analytical laboratory. The results of laboratory analyses were correlated with the ammonia selective electrode readings. It was determined that the difference between the ammonia selective electrode readings and the laboratory results for SBR1 Mixed Liquor was a maximum of 10 percent (see Appendix C). Consequently, daily monitoring of ammonia in the reactors was conducted using the selective electrode. In addition, a composite sample of the treated effluent from each new batch of groundwater was collected and analysed for TSS, VSS, ammonia, TKN, nitrate, sulfate, COD, TOC, DOC, phenols, cyanide, thiocyanate, and arsenic.

The acclimatization of SBR's was performed by feeding SBR1 with raw and SBR2 with pre-treated groundwater. A third SBR (SBR3) was fed raw groundwater and operated to maintain active nitrifying sludge for use as a seed when needed.

In SBR1 and SBR2, mixed liquor temperature, pH and DO were maintained at 30°C (~80°F), 7.5 and >3 mg/L, respectively. Mixed liquor temperature in SBR3 was not maintained but was recorded and was typically in the range 20 - 23°C. The pH and DO in SBR3 were maintained at 7.5 and >2 mg/L respectively.

Biokinetics measurements were conducted regularly (twice a week or sometimes every day) from July through the end of the study in October to better monitor and understand biological processes in both reactors during and after the FILL period. The measurements included DO readings and ammonia analyses. Since each ammonia analyses required 25 mL of mixed liquor, the analyses could not be done too frequently to maintain adequate biomass. These measurements were used to monitor biomass

activity, particularly when changes of operating parameters were implemented. They were also important for monitoring the biomass recovery after upset.

4.2.3 INITIAL ACCLIMATIZATION USING DOFASCO SLUDGE

Acclimatization of the Dofasco sludge was conducted between January 13 and February 5.

Initially, approximately 10 litres of seed sludge (returned activated sludge) from the DOFASCO coke wastewater treatment plant was mixed with 5 litres of potable water, placed in all three reactors (SBR1, SBR2, and SBR3) and aerated. The temperature of the mixed liquor in reactors SBR1 and SBR2 was maintained at 30°C (~80°F) using submersible heaters. Reactor SBR3 was not equipped with a heater and the temperature of the mixed liquor in this reactor was approximately 23°C.

SBR1 started operating on January 13 and was fed raw groundwater. SBR2 started operation January 18, 2003 and was fed groundwater pre-treated for arsenic removal. Initially 500 mL of groundwater were added to the SBR's. Groundwater was also added to reactor SBR3 starting with 10 mL on January 13.

The SBRs achieved nitrification but their nitrification activity was unacceptably low. The low nitrification rate was likely due to the fact that the Dofasco reactor was in the initial stages of upset when the sludge for the SBR start-up was collected. On February 7, 2003, it was therefore decided to start again with fresh sludge from a wastewater treatment plant at US Steel's Clairton works.

4.2.4 ACCLIMATIZATION USING CLAIRTON COKE WORK'S SLUDGE

The acclimatization using Clairton Coke Works sludge is presented in three parts. Parts A and B describe initial acclimatization at 5 days HRT, while Part C describes acclimatization at 7.5 days HRT. Parts A and B provided valuable information regarding the most appropriate procedure for acclimatization of the biomass.

4.2.4.1 PART A: FEBRUARY 9 TO 19, 2003

The sludge from Clairton Coke Works was received on February 8, 2003.

The sludge had 3.6 mg/L of ammonia and 56 mg/L nitrate. The vitality of the microorganisms, as examined under a microscope, was considered to be high and satisfactory.

SBR1 and SBR2 were filled with undiluted sludge while SBR3 had 10 L of sludge and 5 L aerated potable water. Acclimatization in reactors SBR1 and SBR2 started on February 9, 2003 with aeration and warming to 30°C.

Starting on February 11, 2003, both reactors were fed 3,000 mL per day to achieve an HRT of 5 days. In order to start acclimatization with a very low ammonia loading but a constant HRT, feed to the reactors was created by diluting raw or pre-treated groundwater into aerated tap water. SBR1 first received feed consisting of a mixture of 2700 mL of aerated tap water and 300 mL raw groundwater. The feed to SBR2 was a mixture of the same ratio but raw groundwater was replaced by pre-treated groundwater.

SBR3 first received a feed of 100 mL of raw groundwater mixed with 300 mL of water on February 11, 2003.

The ratio of groundwater (raw or pre-treated as appropriate) to tap water was changed so as to gradually increase the ammonia load on the reactor with a constant HRT of 5 days. The ammonia load on the reactors was only increased when the ammonia concentration in the reactor at the end of a REACT period was <3 mg/L. The mixed liquor temperature, pH and D.O were maintained around the desired level of 30°C, 7.5 and >3.0 mg/L, respectively.

The feed was pumped into the reactors taking 18 hours in 6 feeding cycles (one-hour FILL and 2 hours REACT) with only one SETTLE and DRAW period per day. The mixer and aerator were both turned off during the SETTLE and DRAW period to allow the sludge to settle before the supernatant was decanted.

On February 19, both reactors experienced total nitrification upset and feed to SBR1 and SBR2 was stopped.

Reactor SBR3 did not experience an upset and groundwater feed to this reactor was slowly increased to 300 mL/day mixed with 250 to 400 mL of tap water. The tap water was added to compensate for evaporation in the SBR.

4.2.4.2 PART B: FEBRUARY 20 TO MARCH 13, 2003

During this period steps were taken to revive SBR1 and SBR2 to restore the nitrification activities to pre-upset conditions. Simultaneously, steps were taken to upgrade the SBR control arrangement to avoid future nitrification upsets under similar conditions.

Treatment system upgrade:

1. Both reactors were equipped with pH controllers.
2. Each reactor was equipped with two independent aeration systems (air pumps and diffusers).
3. Each reactor was equipped with two electric heaters.
4. A night shift operator was added to check the system operation and monitor pH, DO and ammonia concentration in all three reactors.

Nitrification Recovery:

SBR1 and SBR2 were washed with 3000 mL of aerated tap water daily from February 19 to March 3, 2003 to lower the toxicity in the reactors due to the presence of a high ammonia concentration in the mixed liquors and to revive nitrification. The procedure for washing the biomass consisted of diluting the mixed liquor (ML) with a specified volume of aerated tap water, allowing the biomass to settle, and then decanting the same volume of clarified mixed liquor. In addition, about 300 mL of ML of biomass from SBR3 was also added daily to SBR1 and SBR2.

During the same period the MLTSS in the SBRs was considered to be too high and was lowered to prevent possible sludge settling problems. The following procedure was implemented to reduce the MLTSS in the SBRs:

1. 3000 mL of mixed liquor (ML) was removed from SBR1 and SBR2;
2. The removed ML was treated with 10 mg/L of ferric chloride and 5 mg/L anionic polymer (FL-9, Dearborn, Mississauga, ON);

3. Settled sludge from the 3000 mL mixed liquor samples from SBR1 and SBR2 were added to SBR3, while supernatants were returned to SBR1 and SBR2 respectively; and

4. 100 mL of ML from SBR1 and SBR2 were wasted daily.

This procedure reduced the MLTSS in SBR1 and SBR2.

Feeding was restarted on March 4, 2003 with 200 mL groundwater and 2,800 mL aerated tap water. This was increased to 300 mL groundwater and 2,700 mL aerated tap water on March 5, 2003 and remained at this level until March 14, 2003.

4.2.4.3 PART C: MARCH 14 TO APRIL 1, 2003

Based on data collected from the Dofasco sludge and Parts A and B, a more conservative acclimatization procedure was adopted to avoid the possibility of further nitrification upsets. The volume of feed added to SBR1 and SBR2 was reduced to 2,000 mL per day so that the HRT was increased to 7.5 days thus reducing the ammonia loading. The feed was still a mixture of groundwater or pre-treated groundwater and aerated tap water. The amount of groundwater in the feed was increased only when the final ammonia concentration in the reactor was <1 mg/L. The mixed liquor temperature of 30°C, a pH of 7.5, and the same SBR cycle were used.

The feed during this period started with 400 mL of groundwater mixed with 1600 mL of aerated tap water. The proportion of groundwater in the feed was slowly increased. It required 20 days (3/13 to 4/1) for SBR1 and 17 days (3/13 to 3/30) for SBR2 to achieve 2000 mL of raw feed per day with continued complete nitrification. A lag time of about 3 days. for increasing the groundwater ratio in the feed between SBR1 and SBR2 was deliberately maintained to avoid the possibility of nitrification upset occurring simultaneously in both SBRs due to increased ammonia loading. This was done so that sludge from the normally operating SBR could be pumped to the upset SBR, to stimulate quick recovery.

4.2.5 STEADY STATE OPERATION (APRIL 2 TO MAY 26, 2003)

After the SBR's demonstrated complete nitrification at an HRT of 7.5 days. SBR1 was operated for an additional 7 weeks with all operating conditions fixed. SBR2 was operated for an additional 9 weeks with all operating conditions fixed. This was done to

ensure that the SBR's could demonstrate consistent and complete nitrification for an extended period of time. The collected data provided a baseline for designing the full-scale system.

A computer program run with input of groundwater COD, TKN, ammonia and SCN loading at 7.5 days HRT and 100 days SRT estimated that the mixed liquor TSS of such a system should be approximately 2000 mg/L. This MLTSS was deemed too low to achieve consistent nitrification with groundwater containing 1000 mg/L TKN in the full scale system. Therefore, powdered activated carbon (PAC) was added to the SBRs between April 7 and April 11 to increase the MLTSS. The activated carbon would provide a surface on which the microbes could adhere, thus increasing the concentration of microbes in the SBR. It was therefore decided that the system should be operated with periodic PAC addition so that mixed liquor TSS was maintained at an average concentration of 8000 mg/L.

Sludge wasting of about 100 mL/day was started during this period to maintain a solids retention time (SRT) of 100 days. Between sludge wasting and PAC addition, an SRT of 100 days was maintained.

4.2.6 OPTIMIZATION OF SBR OPERATION (MAY 27 TO OCTOBER 17)

Following achievement of complete and consistent nitrification at an HRT of 7.5 days, experiments were undertaken to optimize the SBR treatment system. Optimization experiments focused on changing those parameters that would have the greatest effect on the cost of construction and operation of a full scale SBR system. These included reductions in HRT, decreased FILL period, decreased temperature, and elimination of arsenic pre-treatment.

4.2.6.1 OPERATION AT 5 DAYS HRT, 30°C AND SIX CYCLES PER DAY

This experiment started with both SBRs receiving 2100 mL of groundwater (raw groundwater for SBR1 and pre-treated groundwater for SBR2) mixed with 900 mL of tap water at a mixed liquor temperature of 30°C, a pH of 7.5 and at the same operational strategy (i.e., 18 hours of alternating 1 hour aerated FILL followed by 2 hour aerated REACT, 1 hour and 40 minute SETTLE, and a 4 hour and 20 minute DRAW). SBR1 received its first 2,100 mL feed on May 27. SBR2 received its first 2,100 mL feed on May 29.

The ratio of groundwater in the feed was slowly increased. On June 2, SBR2 began receiving 3000 mL of raw groundwater and on June 6 SBR1 began receiving 3000 mL of pre-treated groundwater. As used in the previous period, a lag time of about 3 days, for increasing the groundwater ratio in the feed between SBR1 and SBR2 was deliberately maintained, to avoid simultaneous upsets.

Both SBRs achieved complete and consistent nitrification during the 5 day HRT period of operation. Both SBRs were operated at 5 days HRT with the feed containing no dilution water, with other operating conditions unchanged, until June 11, 2003.

4.2.6.2 OPERATION AT 5 DAYS HRT AND 3 CYCLES PER DAY

Up to this point, the SBRs were operated with 6 - 3 hour cycles of 1 hour of aerated FILL and 2 hours of aerated REACT. The operational strategy was modified in stages to reduce the number of cycles from 6 to 3. The operational strategy with three cycles per day consisted of a 1 hour aerated FILL followed by a 5 hour aerated REACT. The 1 hour 40 minute SETTLE and 4 hour 20 minute DRAW period at the end of each day were maintained.

The changes in operational strategy were applied to both SBR1 and SBR2. In addition, the temperature of SBR2 was slowly lowered from 30°C to 25°C at a rate of 1 degree reduction every 2 to 3 days. The temperature reduction was implemented over the period June 26 to July 5. Between August 5 and August 25 the temperature of SBR2 was further reduced to 19°C.

SBR1 was then operated with little change until August 17. During this time, SRT was maintained at around 75 days by wasting and MLTSS was controlled around 8,000 mg/L by activated carbon addition. The arsenic concentration was monitored with the sludge and the treated effluent. Effluent samples were saved for arsenic removal experiments described in Section 4.3.3.

SBR2 was operated with little change until July 28.

It should be noted, that on July 5th, SBR1 experienced a pH increase up to 9.6 because of a pH probe failure. The pH excursion caused a reactor upset. The reactor was allowed to recover without intervention for ten days at which time it had not fully recovered to pre-upset reaction rates. Mixed liquor (1 liter) was transferred from SBR2 to SBR1 to facilitate recovery.

4.2.6.3 OPTIMIZATION EXPERIMENTS IN SBR1:

4.2.6.3.1 EFFECTS OF FERRIC CHLORIDE ADDITION FOR ARSENIC REMOVAL (AUGUST 17 TO SEPTEMBER 12)

Ferric chloride was added daily to SBR1 starting with a dose equivalent to achieve 10 mg/L in the reactor. The daily ferric chloride dose was increased by 10 mg/L approximately every week up to a dose of 80 mg/L to investigate the effect of ferric chloride on effluent arsenic concentrations. SBR1 was then dosed with 40 mg/L ferric chloride for the remainder of the study.

4.2.6.3.2 UPSET RECOVERY (SEPTEMBER 13 TO OCTOBER 3)

The first upset simulated the conditions at a plant when an aeration equipment failure occurs with all other equipment working properly. To investigate the worst case scenario, aeration in SBR1 was discontinued for 14.5 hours, a relatively long period of time, on September 23 while the reactor experienced 2 FILL periods. Such a situation is unlikely to occur in a full-scale system because a PLC should activate an alarm based on equipment failure, ammonia and/or DO measurements.

After the biomass in SBR1 totally recovered the temperature of the mixed liquor was gradually lowered to approximately 22°C. When biokinetics measurements confirmed the ammonia removal rate was similar to that before the upset, another upset was induced.

For the second upset, sodium hydroxide solution was added to raise the pH to 11.4 on September 29. Since the pH controller was set up to adjust an acidic pH the system operated at this elevated pH for almost 12 hours prior to corrective measures being implemented.

4.2.6.3.3 HRT AND TEMPERATURE REDUCTION (OCTOBER 4 TO 17)

The volume of feed to SBR1 was increased to 5,000 mL per day of raw groundwater in order to achieve an HRT of 3 days. Once a 3 day HRT was achieved and continued complete nitrification confirmed, the temperature in SBR1 was reduced to 19°C.

4.2.6.4 OPTIMIZATION EXPERIMENTS IN SBR2:

4.2.6.4.1 TEMPERATURE REDUCTION (JULY 26 TO SEPTEMBER 5)

The temperature of SBR2 was slowly lowered from 25°C to 19°C at a rate of approximately 1 degree every 3 days. Once two series of biokinetic measurements were collected at 19°C, the temperature of SBR2 was returned to 30°C in 24 hours.

4.2.6.4.2 TEMPERATURE REDUCTION AND FERRIC CHLORIDE ADDITION (SEPTEMBER 6 TO OCTOBER 7)

The temperature of SBR2 was slowly lowered from 30°C to 23°C at a rate of approximately 1 degree every three days. SBR2 also began to receive a daily ferric chloride dose of 40 mg/L. The addition of ferric chloride is further described in Section 4.3.

4.2.6.4.3 ANOXIC FILL AND HRT REDUCTION (OCTOBER 8 TO 17)

The operational strategy for SBR 2 was modified such that the there was no aeration, only mixing, during FILL. This was evaluated for 4 days prior to increasing the volume of raw groundwater fed to the reactor in order to lower the HRT to 4 days. SBR2 operated at a temperature of 23°C during this period.

4.2.7 OTHER TESTS

4.2.7.1 RESPIROMETRIC TESTS

Two respirometric tests were conducted during the study. The purpose of these tests was to determine biological oxygen uptake of the biomass during a cycle.

Respirometric tests were conducted using the Comput-OX respirometer manufactured by N-CON Systems, Larchmont, NY. A description of the system and a detailed procedure are presented in Appendix E.

4.2.7.2 SETTLING TESTS

The purpose of sludge settling tests was to determine the settling time required to obtain good quality effluent (TSS <50 mg/L) and a proper design of a full-scale treatment system.

Two settling tests were conducted using a LG-5601 Mallory Direct Reading Settlometer. In addition, measurements of sludge level in both reactors, after settling were also conducted.

4.3 FATE OF ARSENIC IN THE BIOLOGICAL SYSTEM AND TREATMENT ALTERNATIVES

One of the expectations for the groundwater remediation system is a reduction in arsenic concentration at the base of the aquifer. To achieve this goal, arsenic will need to be removed from the extracted groundwater prior to re-injection. Several experiments were undertaken to evaluate the fate of arsenic in the biological reactors, with and without iron addition and to evaluate tertiary treatment options for arsenic removal.

4.3.1 FATE OF ARSENIC WITHOUT IRON ADDITION

SBR1 was fed with raw groundwater and SBR2 was fed with pre-treated groundwater during the initial phases of the study until July 2. After July 2 both reactors were fed with raw groundwater. Data was collected on the influent, effluent, and sludge concentrations of arsenic two times per week from June 2 through July 17 to determine the fate of arsenic in the biological treatment system.

During this period, it was noticed that the mass of arsenic in the effluent and the sludge could not account for the entire mass of arsenic entering the reactors. It was suspected that volatilization of methylarsenic compounds may account for the remaining mass of arsenic. Therefore, an experiment was undertaken to determine if arsenic was being lost due to volatilization.

500 mL of settled sludge, collected from both reactors was placed in a 1 L - flask equipped with an aeration system at the bottom and connected to an impinger with 100 mL of absorbing solution (0.1 percent solution of ferrous sulfate and 0.05 percent hydrogen peroxide at pH 3.5 adjusted with sulphuric acid).

The sludge in the flask was slowly aerated for 10 hours and all off-gases passed through the absorbing solution. The test was conducted in triplicate for different air flows: 50 mL/min, 100 mL min, and 200 mL/min.

Sludge samples as well as impinger solutions were analysed for arsenic before and after the tests.

4.3.2 ARSENIC REMOVAL BY FERRIC CHLORIDE ADDITION IN THE SBR

As presented above, ferric chloride was added to both reactors to evaluate the efficacy of iron precipitation of arsenic within the biomass. Ferric chloride addition began on August 18 for SBR1 and September 1 for SBR2. The ferric chloride dose to SBR1 was started at 10 mg/L and increased to 80 mg/L to evaluate the effects of ferric chloride dosage on arsenic removal. For the final month of the study, 40 mg/L of ferric chloride (determined to be the optimal dose) was added daily to both reactors to evaluate the long term effects of ferric chloride addition. Influent, effluent, and sludge samples were analyzed for arsenic during this period.

At the end of the study, sludge samples from both reactors were collected and evaluated for hazardous waste characterization using the toxic characteristic leaching protocol (TCLP).

4.3.3 TERTIARY ARSENIC TREATMENT

As presented earlier in this section, it was determined that pre-treatment of the groundwater for arsenic was not required in order to achieve complete and sustained nitrification for arsenic concentrations up to 11 mg/l, the maximum concentration experience in this study. Therefore, additional experiments were undertaken to evaluate the following approaches for the removal of arsenic from the SBR effluent.

- precipitation with ferric chloride;
- precipitation with ferrous sulfate;
- precipitation with ferrous sulfate and humates;
- Fenton's reagent treatment with humates at a pH of 7.4;
- Fenton's reagent treatment at a pH of 3.5; and
- activated alumina adsorption.

The effluent samples for these experiments were collected separately from both reactors over two weeks and stored at 5°C before the tests. The concentration of arsenic in these samples was 5.3 mg/L (SBR1 effluent) and 2.6 mg/L (SBR2) effluent.

All of the tertiary arsenic treatment experiments were completed by placing 100 mL of effluent into a beaker that was equipped with a magnetic stirrer. The effluent samples were stirred and the chemicals were added at varying dosages. The solution in the beaker was stirred for 30 minutes and then suspended solids were allowed to settle quiescently. Samples of the clarified solution were then collected for analysis.

5.0 RESULTS

5.1 ARSENIC PRETREATMENT

The results of the arsenic pre-treatment experiments are presented in Table 5.1.

The results indicate that the previously developed pre-treatment method can achieve treatment objectives for arsenic removal from the representative groundwater. The treatment using 50 mg/L hydrogen peroxide removed 90% of the arsenic, 90% of the cyanide, 18% of the thiocyanate and 18% of phenols from the representative groundwater.

This treatment (50 mg/L hydrogen peroxide) was then applied to all 11 batches of representative groundwater that were used to feed biological reactor SBR2. Samples from each batch of pre-treated groundwater were analysed for pH, TSS, VSS, COD, TOC, DOC, phenols, arsenic, ammonia, nitrate, cyanide, and thiocyanate. A summary of analytical results for these batches is presented in Table 5.2. Initial and pretreated analytical results for all individual batches are presented in Appendix D.

Comparing the raw and pre-treated results for arsenic in Appendix D indicates that Fenton's reagent treatment of groundwater achieved an average of 76.5 ± 13.5% removal of arsenic from WCP groundwater with an initial arsenic concentration in the range of 6 to 10 mg/L.

The settled solids from the pre-treatment were separated from the treated liquor by sedimentation. As the solids settled well, organic flocculent was not required to achieve solids separation. Settling tests, for selecting the size of a clarifier in a full scale system, were considered unnecessary.

5.2 ACCLIMATIZATION

5.2.1 ACCLIMATIZATION USING DOFASCO SLUDGE (JANUARY 13 TO FEBRUARY 5)

Reactors SBR1, SBR2, and SBR3 were initially seeded with activated sludge from the DOFASCO coke wastewater treatment plant. A summary of analytical data and operational parameters for each of the three reactors is presented in Tables 5.3, 5.4, and 5.5.

Reactors SBR1 and SBR2 were fed periodically with small (500 mL to 650 mL) amounts of raw and pretreated groundwater on five occasions between January 13 and January 31. Reactor SBR3 was fed daily with raw groundwater starting at 10 mL/day and increasing as indicated in Table 5.5.

The nitrification performance of these reactors, as indicated by the ammonia concentrations in Tables 5.3, 5.4, and 5.5 was unacceptably slow and operation with DOFASCO sludge was discontinued. A possible cause of the unacceptably low nitrification rate may have been the stressed state of the biomass when received. It was determined that future start-up operations would include:

- undiluted biomass;
- confirmation of biomass good health; and
- diluted feed.

5.2.2 ACCLIMATIZATION USING CLAIRTON COKE WORKS SLUDGE

This section describes acclimatization using Clairton Coke Works Sludge to seed the SBRs with microbes. As described in Section 4.2.4, the acclimatization was conducted in three parts. Summary tables of data are referenced throughout the following discussion. A listing of data that is based on the Clairton Coke Works Sludge as seed is presented in Appendix E.

Part A (February 9 to February 19)

From February 9 to February 19, the HRT in reactors SBR1 and SBR2 was initially 5 days and the feed (3000 mL per day) was a mixture of 2700 mL of aerated tap water and 300 mL groundwater. The content of the groundwater in the influent to both reactors was gradually increased to 1000 mL over 7 days.

The feed was pumped into the reactors during 18 hours in 6 feeding cycles (one-hour aerated FILL and 2 hours aerated REACT). Analytical data and operational parameters for SBR1, SBR2, and SBR3 for Part A are presented in Tables 5.6, 5.7, and 5.8, respectively. TKN load and effluent ammonia concentrations are presented graphically against time on Figures 5.1 and 5.2, respectively. Note that TKN load on the figures is presented in mg/day while TKN load in the tables is presented in mg/L of mixed liquor. Multiplying the TKN load in the tables (mg/L) by the 15L volume of the reactors converts the TKN load in (mg/L) to TKN load in (mg/day).

During the first 8 days, the concentration of ammonia in the effluent from SBR1 and SBR2 decreased from 3.2 mg/L on February 9 to 0.15 mg/L in SBR1 and 0.3 mg/L in SBR2 on February 17. At the same time, the concentration of nitrates increased from 56 mg/L to 120 mg/L in SBR1 and 110 mg/L in SBR2 indicating nitrification was occurring.

When the groundwater content of the feed increased to 1000 mL (February 18) the pH became unstable and fluctuated despite manual adjustment by the addition of a soda ash solution. At times during the period February 18 to 19, the SBRs experienced pH conditions <6.5. On February 19, both reactors experienced total nitrification upset, likely as a result of the unstable pH. The groundwater feed was discontinued.

Reactor SBR3 did not experience an upset and continued to be fed daily with 300 mL of raw groundwater. The mixed liquor from this reactor was later used to seed SBR1 and SBR2 during their recovery from upset.

Part B (February 20 to March 12)

From February 20 to March 5, SBR1 and SBR2 were washed with aerated tap water to decrease the ammonia concentration in the mixed liquor and stimulate nitrification. In addition, about 300 mL/day of biomass from SBR3 was added to SBR1 for 4 days and to SBR2 for 5 days. Once the ammonia concentration in the effluent decreased below 1 mg/L, the feed was re-started. On March 4, SBR1 was fed with a mixture of 200 mL raw groundwater and 2800 mL aerated tap water while SBR2 was fed with a mixture of 200 mL pre-treated groundwater and 2800 mL aerated tap water. This feed rate was increased to 300 mL groundwater mixed with 2,700 mL aerated tap water and continued at that rate until March 12. A summary of operational parameters and analytical data for the influents and effluents is presented in Tables 5.9 and 5.10.

TKN load in mg/day and NH_3-N concentration in the effluent for this acclimatization period are presented on Figures 5.3 (SBR1) and 5.4 (SBR2). The figures illustrate the recovery of nitrification in both reactors using a combination of sludge washing and seeding from SBR3. The results of this recovery were used to develop the upset recovery procedure tested at the end of the study.

Part C (March 13 to April 1)

During Part C, as described in Section 4.2.4.3, a more conservative acclimatization strategy was implemented that included an initial increase in the HRT to 7.5 days.

During this operating period, the daily load of TKN to SBR1 and SBR2 increased from 315 mg/day to 1575 mg/day (21 mg/L to 105 mg/L in the mixed liquor). The average effluent NH_3-N concentration from SBR1 was 0.4 ± 0.6 mg/L and from SBR2 was 0.5 ±1.5 mg/L during this period. Operational parameters and analytical data for reactors SBR1 and SBR2 are presented in Tables 5.11 and 5.12, respectively. On March 18, consistent with the treatment system upgrade described in Section 4.2.4.2, a night shift began operation and three readings of operational parameters are presented for each day.

TKN load in mg/day and NH_3-N concentration in the effluent are presented on Figures 5.5 (SBR1) and 5.6 (SBR2). On March 26, high ammonia concentrations in SBR2 resulted in the feed being stopped before the full feed was completed. This event was quickly traced to a faulty pH electrode allowing the pH to drop, resulting in temporary inhibition of nitrification. The pH electrode was replaced and the normal feeding schedule resumed on March 27. The event was identified and corrected quickly and consequently does not affect the daily data presented on Figure 5.6.

A similar event occurred in SBR1 on April 2. Full feed resumed on April 3.

5.3 STEADY STATE OPERATION (APRIL 2 TO MAY 26)

During steady state operation both reactors operated at 7.5 days HRT and at 30°C. SBR1 was fed raw groundwater. SBR2 was fed pre-treated groundwater. Operational data for this period of the study are presented in Tables 5.13 and 5.14 for SBR1 and SBR2, respectively. Results for TKN load in mg/day and NH_3-N concentration in the effluent are presented on Figures 5.7 and 5.8 for SBR1 and SBR2, respectively.

The data indicate that in both reactors SBR1 and SBR2 robust microbial consortia were enriched that could consistently meet all treatment objectives for organics, phenol, thiocyanate, and ammonia. The acclimation procedure and the SBR operating strategy were capable of providing the necessary environment to achieve complete and consistent nitrification at 7.5 days HRT and 30°C.

It is very important to note that both SBR1 and SBR2 demonstrated similar treatment efficiencies even though their influent arsenic levels were significantly different. Therefore, it was concluded that pre-treatment of groundwater for arsenic is not required to achieve complete and consistent nitrification within the range of influent arsenic concentrations used in this study (i.e., ≤ 11 mg/L). However, in order to

evaluate the potential impact of arsenic concentration on the biological system during the next stages of the study (reduced HRT, lower temperature and reduction of number of cycles), SBR2 was still fed with pre-treated groundwater.

As acclimatization was progressing MLVSS decreased, particularly in SBR1 (MLVSS = 6400 mg/L). This decrease was the result of loosing mixed liquor (ML) for ammonia and TSS/VSS analyses, which was in excess of the biomass yield. This led to a concern that MLVSS would continue to decrease, as discussed in Section 4.2.5, leading to reduced reactions rates and difficulties in settling of the biomass. It was determined, using a mathematical model of the biological system that an appropriate level of MLVSS for the next stage of the study would be 8,000 mg/L. Therefore the concentration of the biomass was gradually increased by adding powder activated carbon (PAC), which both added solids to the biomass and provided surface area for bacteria to attach. ML solids concentrations were then managed by a combination of PAC addition and daily wasting of ML.

5.4 OPTIMIZATION OF SBR OPERATION (MAY 27 TO OCTOBER 17)

5.4.1 OPERATION AT 5 DAYS HRT, 30°C AND 6 CYCLES PER DAY

During this stage of the study both reactors were fed with 3000 mL of a mixture of the groundwater and tap water. The initial raw groundwater content fed to SBR1 was 2000 mL on May 26 and was gradually increased to 3000 mL on June 6. The initial pre-treated groundwater content fed to SBR2 was 2000 mL on May 28 and gradually increased to 3000 mL on June 9. The analytical and operational data for SBR1 and SBR2 for this stage of the study are presented on Tables 5.15 and 5.16, respectively. TKN load in mg/day and NH_3-N concentrations in the effluent for this period are presented on Figures 5.9 and 5.10. The data demonstrate that the microbial consortia in both reactors could acclimate to the increased organic and ammonia loading of a 5 day HRT while continuing to achieve complete and consistent nitrification.

During this period, biokinetic evaluations were initiated. The data from the biokinetic experiments are presented in Appendix F. The DO at the end of FILL was typically around 2.5 mg/L. The DO increased to greater than 80% of the pre-FILL period DO within 60 minutes following the end of FILL (DO recovery). The DO recovery roughly coincided with the concentration of ammonia dropping below 1 mg/L. Both the ammonia concentration dropping below 1 mg/L and DO recovery occurred in less than 60 minutes after FILL in both reactors.

5.4.2 OPERATION AT 5 DAYS HRT, 30°C AND 3 CYCLES PER DAY

5.4.2.1 SBR1

After reducing the HRT to 5 days the feed rate was increased as described in Section 4.2.6.2. A summary of operational data for SBR1 operated at 5 days HRT and 30°C is presented in Table 5.17. TKN load in mg/day and NH_3-N concentrations in the effluent under these operating conditions are presented on Figure 5.11. The concentration of ammonia in the effluent was below 0.1 mg/L at the end of REACT despite increasing the load of TKN in the influent from 1860 mg/day to 2370 mg/day (124 mg/L to 158 mg/L in the mixed liquor). In fact, the ammonia concentration in the effluent decreased from 0.08 mg/L to 0.03 mg/L during this operational period despite the increase in ammonia loading.

It is also worth noting that during one month of operation, the MLVSS in SBR1 decreased from 7300 mg/L to 5400 mg/L but the ammonia concentration continued to be reduced to less than 1.0 mg/L in less than 30 minutes (Appendix F). This represents an increase in the ammonia loading rate from 0.017 mg TKN per mg of VSS per day (mg TKN/mg VSS-day) to 0.029 mg TKN/mg VSS-day. The ability of less biomass to nitrify more ammonia in the same period of time was a result of acclimating the microbial consortia to 1,000 mL fed over a 1 hour FILL period with 3 cycles per day versus 500 mL added over the 1 hour FILL when 6 cycles per day were used.

Biokinetics evaluations for SBR1 (Appendix F) continued to show significant DO sag at the end of FILL and DO recovery in less than 60 minutes. The DO recovery continued to correlate with the ammonia concentration dropping below 1 mg/L.

On July 5, a pH probe failure caused the pH of SBR1 to increase causing an upset. Biokinetics data clearly show a small DO sag during the initial portion of FILL, so the feed was changed to only tap water at 20 minutes into the FILL. The remainder of the FILL and REACT showed very little DO sag and very slow nitrification (i.e., 6.4 mg/L ammonia still remained after 90 minutes). The subsequent days continued to show this DO profile and high ammonia concentrations that indicated that the biomass had not recovered. Five days after the upset, the ammonia concentration was less than 1 mg/L after 24 hours but the DO profile and ammonia profile still indicated significant reduction in biomass activity. Recovery of the biomass was tracked over the next 12 days until the DO at the end of FILL was again approximately 2 mg/L, the DO

returned to within 80% of the pre-FILL DO in less than 60 minutes, and the ammonia concentration was reduced to less than 1 mg/L in less than 60 minutes.

Evaluation of the data from the SBR1 upset recovery allowed for the definition of healthy biomass when operating at 30°C. DO at the end of FILL of 2.0 to 2.5 mg/L and recovery of the DO to 80% or greater of the pre-FILL DO were determined to correlate very closely with complete and consistent nitrification. This DO profile was used throughout the remainder of the study to evaluate the overall health of the biological system in real-time. Deviation from this profile correlated with reductions in reaction rate. An increasing trend in the time required for DO recovery was indicative of a potential upset when operating parameters were constant. A decreasing trend in the time required for DO recovery was indicative of improvement in the overall health of the biological system.

5.4.2.2 SBR2

Up to June 26, the operational data and biokinetic evaluations showed little difference between the treatment performance of the microbial consortia in SBR1 and SBR2. Therefore, it was concluded that influent arsenic concentrations less than 10 mg/L did not affect complete and consistent nitrification. Therefore, on June 26, the feed to SBR2 was changed to raw groundwater and remained raw groundwater for the duration of the study.

In addition to changing the feed rate, as described in Section 4.2.6.2, the temperature of the mixed liquor in SBR2 was gradually lowered from 30 to 25°C, beginning on June 26. Non-contact cooling was provided by potable water circulating in a copper coil.

Operational data for SBR2 operated at 5 days HRT and 25°C is presented in Table 5.18. Changes in TKN load and ammonia effluent are shown on Figure 5.12. As indicated in Table 5.18 and illustrated on Figure 5.12, the TKN load was reduced on July 17 and then increased on July 23 without creating any substantive change in effluent quality (Changes in TKN loading were due to variations in feed batches).

The concentration of ammonia in the effluent was consistently below 0.2 mg/L while TKN load in the influent ranged from 1770 mg/day to 2460 mg/day (118 mg/L to 164 mg/L mixed liquor). At the same time MLVSS ranged from 4900 mg/L to 6600 mg/L and the ammonia loading rate was relatively constant at 0.024 mg TKN/mg VSS-day.

Biokinetics measurements confirmed that the nitrification rate initially decreased with each temperature decrease (Appendix F). A decrease in the nitrification rate was indicated by an increase in the time for DO recovery and the time required for the ammonia concentration to decrease to 1 mg/L. By the end of this operational period, SBR2 was achieving DO recovery and ammonia concentration of less than 1 mg/L in less than 60 minutes following FILL at an operating temperature of approximately 25°C.

5.4.3 OPTIMIZATION EXPERIMENTS IN SBR1

As indicated in Section 4.2.6.2, the reactors were operated with little change through July. A rapid FILL (feed) cycle and 5-day HRT were maintained through this period of time. The temperature of SBR1 was maintained at 30°C while the temperature of SBR2 was reduced to 19°C over several days. On August 14, a major power failure occurred lasting approximately 7.5 hours. As the SBRs did not receive any feed during this period they revived fully when power was restored. The normal feed cycle resumed the next day.

5.4.3.1 UPSET RECOVERY (SEPTEMBER 13 TO OCTOBER 3)

The temperature in SBR1 was gradually lowered from 30°C to 21°C over a period of 5 days in preparation for an induced upset. The reactor temperature was lowered to 21°C because results from SBR2 suggested that 21°C would be the lowest design operating temperature. It was observed that a relatively fast temperature decrease had no impact on the concentration of ammonia in the effluent, which was <0.1 mg/L during this period.

As expected the biokinetic rate (Appendix F) decreased with the temperature from 0.52 mg NH_3-N/min at 30°C to 0.39 mg NH_3-N/min at 22°C. At the same time the DO drop during the feed cycle was substantially lower at 22°C (~2.2 mg O_2/L) as compared to that at 30°C (~4.3 mg O_2/L). This phenomenon is consistent with the expected decrease in oxygen uptake rate and the expected increase in the oxygen transfer rate due to the higher oxygen solubility of water at lower temperatures.

5.4.3.1.1 INDUCED UPSET #1 AND RECOVERY (SEPTEMBER 22 TO SEPTEMBER 25)

On September 22, to induce the first upset, SBR1 was fed twice with 1000 mL of raw groundwater (2000 mL total) without aeration for 13 hours. The mixer was operating all the time except during 100 minutes of SETTLE. The pH controller was also operating so the pH was kept within the desired range 7.2 to 7.8.

The operational and analytical data before and after the induced upset is presented in Table 5.19. Data during the upset is presented in Table 5.19a.

As a result of this upset the concentration of ammonia in the mixed liquor increased initially to 29 mg/L and after a second FILL period to 66.5 mg/L.

The following recovery procedure was applied to this upset:

1) Temperature increase and aeration

The first step was to increase the temperature of the mixed liquor (ML) from 22 to 30°C and turn on aeration to activate the biomass. At this time washing also was started. The temperature increase was completed in three hours.

2) Washing

The ML in the reactor was washed 3 times with 3000 mL of aerated tap water. After the addition of 3000 mL of water the ML was mixed and aerated for one hour and was then allowed to settle for 100 minutes. 3000 mL of supernatant was discharged and 3000 mL of new washing water was added. The procedure was repeated two more times. The supernatant, after washing was analyzed for ammonia. After the three washings, the ammonia concentration in the reactor was less than 1 mg/L.

3) Seeding

Once the concentration of ammonia in the ML decreased below 1 mg/L, 3000 mL of ML from SBR2 was transferred to SBR1. After mixing and aeration 3000 mL of ML from SBR1 was transferred to SBR2.

4) Feeding

When the first 3000 mL ML seeding exchange between two reactors was completed, SBR1 was fed with 1000 mL of 50 percent raw groundwater and 50 percent tap water. During the feed cycle biokinetic measurements were conducted. They indicated typical DO decrease during FILL. After FILL was completed the ammonia concentration increased to 8.5 mg/L but over the course of an hour decreased to 0.5 mg/L which indicated that the biomass was nitrifying. A second feeding with 50% raw groundwater showed similar nitrification results.

After the second seeding, SBR1 was fed with another 1000 mL of a mixture consisting of 75 percent raw groundwater. Again, biokinetics measurements were conducted and showed that the ammonia concentration was reduced to less than 1 mg/L, this time within two hours following FILL. Within two days following the upset, biokinetic evaluations had returned to the pre-upset conditions. The detailed procedure and the results of ammonia, pH, and DO measurements are presented in Table 5.19a.

In addition to biokinetics measurements, three samples were collected and sent to Agat Laboratory in Mississauga, Ontario for Microtox analyses. These ML samples were collected immediately after the upset, after the third washing, and after the first seeding. The results of these analyses are presented in Appendix G.

Samples of the effluent before and during the upset were also collected and analysed for ammonia, COD, DOC, pH, phenols, thiocyanate, TKN, total cyanide, TOC, TSS, arsenic, nitrate and sulfate. Results of these analyses are presented in Table 5.20. A comparison of the data for the effluent before and after the upset indicates that the upset mostly affected removal of ammonia and thiocyanate. NH_3-N was 0.05 mg/L (TKN <0.2 mg/L) before and 59 mg/L (TKN 170 mg/L) after upset and thiocyanate was 2.8 mg/L before and 1.0 mg/L after upset.

The upset had much less impact on the removal of the organic load expressed as COD (120 mg/L before and 150 mg/L after) and TOC (44 mg/L before and 46 mg/L after).

5.4.3.1.2 INDUCED UPSET # 2 AND RECOVERY

On September 29, the second upset was initiated in SBR1 by adding sodium hydroxide during FILL (1000 mL of raw groundwater added during FILL) to increase the reactor pH to 11.4. This resulted in a substantial increase in the mixed liquor ammonia

concentration to 46.3 mg/L. At the same time intense foaming was observed in the reactor, which is an indication of significant cell lysis occurring due to cell death.

The following recovery procedure was applied:

1) Neutralization and temperature increase

The first step in the recovery from upset was to decrease the pH to 7.5 in the reactor by adding phosphoric acid. The temperature was also increased to 30°C to stimulate biological processes. These actions were initiated approximately 12 hours after inducing the reactor upset.

2) Washing

The ML in the reactor was washed 3 times with 3000 mL of tap water. The washing procedure, as presented in the previous section, was repeated two more times. The supernatant, after washing was analysed for ammonia. Table 5.19b shows that the ammonia concentration was reduced to 3.8 mg/L after three washings.

3) Seeding

3000 mL of ML from SBR1 was exchanged with SBR2. This biomass exchange between two reactors was repeated twice a day for two consecutive days with the same volume (3000 mL) of mixed liquor. After each exchange biokinetics measurements were conducted.

4) Feeding

When the first 3000 mL ML exchange between two reactors was completed, a 1000 mL feed to SBR1 was added. This feed contained 50 percent raw groundwater and 50 percent tap water. During the feed cycle biokinetic measurements were conducted. After FILL was completed the ammonia concentration in the ML increased to 16.6 mg/L. It required more than 3 hours to reduce the ammonia concentration below 1.0 mg/L. Thus, the biomass was nitrifying, however biokinetics were slower than the recovery from upset #1. To increase the biokinetics more ML was exchanged between SBR1 and SBR2.

After the second seeding, SBR1 was fed with another 1000 mL of a mixture comprised of 50 percent raw groundwater. Again, biokinetics measurements were conducted. The

nitrification rate was increasing, so the next 1000 mL feed contained 75 percent raw groundwater and eventually the reactor was fed with the undiluted raw groundwater.

Within 3 days following the upset, SBR1 was receiving 1,000 mL of raw feed per cycle and was reducing the ammonia concentration to less than 1 mg/L within 90 minutes. It should be noted that nine days was required for SBR1 to return to pre-upset biokinetics (Appendix F).

Details of the recovery procedure as well as associated analyses and measurements are presented in Table 5.19b.

As was the case during the first induced upset, three samples were collected and send to Agat Laboratory in Mississauga, Ontario for Microtox analyses. The results of these analyses are presented in Appendix G.

Samples of the effluent before and after upset were also collected and analysed for ammonia, COD, DOC, pH, phenols, thiocyanate, TKN, total cyanide, TOC, TSS, arsenic, nitrate and sulfate. Results of these analyses are presented in Table 5.21. A comparison of the data for the effluent before and after the upset demonstrates that the pH increase strongly affected not only ammonia, TKN and thiocyanate removal but also substantially reduced organics removal. TKN in the effluent before the upset was 1.2 mg/L while after upset 60 mg/L. Thiocyanate concentration in the effluent before the upset was 3.2 mg/L and after the upset was 21 mg/L. The respective values for COD were 170 mg/L before and 380 mg/L after while for TOC was 32 mg/L before and 110 mg/L after the upset.

Based on these data and the longer recovery time after the second upset it was concluded that the pH induced upset had a much more severe impact on the biomass as compared to the upset related to a malfunction of the aeration equipment. This conclusion should be taken under consideration in full-scale system design.

5.4.3.2 HRT AND TEMPERATURE REDUCTION (OCTOBER 6 TO 17)

After reactor SBR1 totally recovered from the second induced upset, the feed to this reactor was gradually increased to 5000 mL per day thus reducing HRT to 3 days. At the same time the FILL period was extended to 100 minutes. The reactor operated at these conditions for a week continuing to produce effluent with ammonia concentration <0.15 mg/L.

It was also found that biokinetics of ammonia removal were not affected by the higher load of TKN despite the increase of ammonia concentration at the end of FILL up to 35 mg/L. This was indicated by a consistent DO profile during FILL and REACT, DO recovery in less than 60 minutes following FILL and the ammonia concentration was reduced to less than 1 mg/L in less than 60 minutes following FILL (Appendix F).

After reducing the HRT in SBR1 to 3 days, the temperature was gradually decreased to 19°C as the heaters were turned off. The reactor operated at these conditions for a week. The concentration of ammonia in the effluent was <0.1 mg/L under these operating conditions. At the same time consistent biokinetics of ammonia removal was also observed though 90 to 120 minutes were required to decrease the ammonia concentration to less than 1 mg/L and achieve DO recovery following FILL.

5.4.4 OPTIMIZATION EXPERIMENTS IN SBR2

5.4.4.1 TEMPERATURE REDUCTION (JULY 26 TO SEPTEMBER 5)

From July 26 to August 17, the temperature of SBR2 was reduced from 25°C to 20°C at a rate of 1 degree every 2-3 days. Reactor SBR2 was then operated at 5 days HRT, ~20°C and one hour aerated FILL for 12 days from August 17 to August 29. During that time, the TKN load in the influent varied from 2130 mg/day to 3000 mg/day (142 mg/L to 200 mg/L in the mixed liquor). Despite these variations, the ammonia concentration in the effluent was consistently <1 mg/L.

Biokinetics measurements (Appendix F) indicated very stable values for DO sag but the DO at the end of FILL was higher than when operating at 30°C. The lower temperature did lower the reaction rates such that 300 minutes were required following FILL to decrease the ammonia concentration to less than 1 mg/L. In addition, 300 minutes was required for DO recovery. Even with the reduction in reaction rate, the microbial consortia under this SBR operating strategy could still achieve all the treatment objectives.

5.4.4.2 MIXED FILL AND HRT REDUCTION

SBR2 operated with a mixed FILL (no aeration) and aerated REACT from October 7 to October 13. The purpose of this optimization was to investigate the possibility of added denitrification during the SBR cycle. During this time, the concentration of ammonia in the effluent was still less than 1 mg/L as indicated in Table 5.22.

At the end of the mixed FILL cycle, the DO concentration was ~0.02 mg/L and the ammonia concentration was 31 to 36 mg/L. Once aeration was activated, the DO concentration increased to >4.5 mg/L. The ammonia concentration decreased but a longer time (3 hours) was required to remove the ammonia to a concentration <1 mg/L.

The potential benefits to be obtained in a full scale system from this mode of operation are:

1) lower concentration of nitrates in effluent;
2) lower total oxygen demand; and
3) denitrification restores alkalinity, counter balancing some of the acidification from ammonia conversion.

The volume of feed to SBR2 was increased to 4,000 mL from October 14 to October 17, which decreased the HRT to approximately 4 days. Again, the concentration of ammonia in the effluent remained below 1 mg/L at all times as indicated in Table 5.22.

DO and ammonia measurements in the ML after the FILL cycle were similar to those for 5 days HRT, except that the ammonia concentration was higher (40.3 mg/L) due to higher TKN load.

Analytical data for the effluent produced by the reactor SBR2 during the last stage of the study, as shown in Table 5.23, indicate that the quality of the effluent was as good as for the operation with aerated FILL. As expected the concentration of nitrates in the effluent was lower indicating that denitrification (conversion of nitrate to nitrogen gas) was occurring.

5.5 ADDITIONAL TESTING

5.5.1 RESPIROMETRIC TESTS

During the first respirometric test, six respirometric reactors were fed with mixed liquor from SBR2 and with various amounts of raw groundwater from the Site. Respirometric plots for this test, presented in Appendix H, demonstrate that oxygen uptake was very high and similar despite differences in the amount of the groundwater added.

Analyses of reactor content revealed a high concentration of ammonia in all of them, similar to that at the beginning of the tests suggesting that nitrification was inefficient due to oxygen transfer limitation. These limitations are related to the specific set up of the respirometric reactors.

The next test was conducted with a much smaller amount of biomass to avoid oxygen transfer limitation. The amount of raw groundwater added to the respirometric reactors was in the same ratio as the feed volume during one feed cycle to MLVSS. The respirometric test was conducted until steady endogenous respiration occurred. A very low concentration of ammonia (<0.05 mg/L) in all reactors confirmed that nitrification was completed.

5.5.2 SLUDGE SETTLING TESTS

The purpose of sludge settling tests was to determine the settling time required to obtain good quality effluent (TSS <50 mg/L) and a proper design of a full-scale treatment system.

The results of this test are summarized in Table 5.24. They indicate that just after 20 minutes the sludge was well settled and later on only compression of solids occurred.

During the second test mixed liquor from the reactor, SBR1 was tested in the settlometer for 100 minutes, which was the settling time for this reactor. The results of this test, as presented in Table 5.25 indicate that the sludge settling occurred during the first 30 minutes.

At the final stage of the study, settling of sludges was monitored in both reactors by measuring the level of sludges after the settling cycle (just before the effluent discharge). The results presented in Table 5.26, indicate a good settling in both reactors.

5.6 FATE OF ARSENIC IN THE BIOLOGICAL SYSTEM AND TREATMENT

5.6.1 REMOVAL OF ARSENIC DURING BIOLOGICAL TREATMENT WITHOUT FERRIC CHLORIDE ADDITION

As presented on Figure 5.13, initial removal of arsenic during biological treatment in SBR1 was significant (approximately 70 percent). After three months of operation, the

arsenic removal became less efficient (approximately 30 percent) and the concentration of arsenic in the effluent became closer to that in the influent. In addition, an increasing concentration of arsenic in the influent resulted in a similar increasing arsenic concentration in the effluent. A generally similar trend is seen in Figure 5.14 for SBR2.

The above observations suggest that the biomass has a specific sorption capacity for arsenic. When equilibrium between the arsenic concentration in the sludge solids and water is established, any arsenic over the equilibrium concentration ends up in the effluent.

To better understand the arsenic fate during biological treatment, samples of sludges and the effluent from both reactors were collected twice a week from June 2 to July 17 and analysed for arsenic.

Results of these analyses are presented in Table 5.27. They indicate that an increased concentration of arsenic in sludges results in decreasing removal of arsenic from the influent. These results support the hypothesis that the biomass has a finite capacity to sequester arsenic.

5.6.2 TESTS ON ARSENIC VOLATILIZATION FROM BIOMASS

Based on the results presented in Table 5.27, a mass balance for arsenic was calculated. Results of these calculations are summarized in Appendix I. The arsenic mass balances suggested that all of the influent arsenic could not be accounted for by the mass contained in the effluent and the sludge. Based on these results, an experiment was undertaken to determine if arsenic was being lost through volatilization.

Sludge samples as well as impinger solutions were analysed for arsenic before and after the tests. Results of these analyses are presented in Table 5.28.

The results demonstrate that the concentration of arsenic in the sludge decreased after aeration. At the same time the concentration of arsenic in the absorbing solution increased. This clearly indicates that a portion of the arsenic in the biomass exists in the form of volatile compounds that can be remove from the sludge during aeration.

The results of these tests are indicative not quantitative. The substantial difference between the amount of arsenic removed from the sludge and that accumulated in the impinger is likely the result of many factors that affect adsorption/immobilisation of volatile arsenic compounds in adsorbing solutions. These factors were not investigated

as they were outside the scope of the work plan but they indicate that arsenic in air should be considered in the final design.

5.6.3 ARSENIC REMOVAL FROM THE MIXED LIQUOR

As discussed in Section 5.3, the pre-treatment of groundwater, primarily for arsenic removal, had no significant effect on biological processes. It was also found that arsenic accumulation in the biomass eventually would result in an elevated concentration of arsenic in the effluent, as demonstrated on Figures 5.13 and 5.14.

Alternatives to pre-treatment were evaluated, which included precipitation in the biological reactor and post-treatment. In this section, the removal of arsenic during biological treatment is discussed. Tests on arsenic removal from the effluent are discussed in Section 5.6.5.

The addition of ferric chloride to a biological system for removing arsenic is a common practice. Successful application of this method depends however on the chemistry of the water to be treated.

To investigate the applicability of this method for arsenic control in groundwater from the WCP Site during biological treatment, a two stage approach was applied:

- addition of an increasing dose of ferric chloride over time; and
- addition of the same dose of ferric chloride over an extended time.

During both tests, ferric chloride, in the form of a 0.1 percent solution, was added manually during the FILL period.

The initial 10 mg/L dose of ferric chloride in SBR1, was increased every 2 to 3 days by 10 mg/L to a maximum dose of 80 mg/L. The concentration of arsenic in the effluent and sludges was monitored twice a week. Typically, two samples were collected for a specific dose of ferric chloride. Results of arsenic analyses along with the ferric chloride dose are presented in Table 5.29.

As shown in Table 5.29, the addition of ferric chloride resulted in a decrease of arsenic concentration in the effluent from both reactors. Thus ferric chloride enhanced arsenic removal with the biomass. The removal efficiency was not however directly proportional to the ferric chloride dose. The addition of ferric chloride up to 40 mg/L

reduced the arsenic concentration in the effluent from SBR1 from 6.3 mg/L to 2.3 mg/L. A higher dose of ferric chloride, up to 80 mg/L reduced the arsenic concentration in the effluent only to 1.9 mg/L.

A similar effect of ferric chloride addition on arsenic removal was observed for SBR2. The addition of 30 mg/L of ferric chloride reduced the arsenic concentration in the effluent from 6.4 mg/L to 3.3 mg/L. For 70 mg/L of ferric chloride added to this reactor the arsenic concentration in the effluent was 2.1 mg/L.

Based on the results from SBR1 and SBR2, a ferric chloride dose of 40 mg/L was selected for long-term evaluation.

From September 19 to October 17, the same 40 mg/L dose of ferric chloride was added to both reactors. Ferric chloride addition resulted in a consistent decrease of arsenic concentration in the effluent from both reactors. Thus at the end of the study, the concentration of arsenic in the effluent from SBR1 was 0.63 mg/L and in the effluent from SBR2 was 0.64 mg/L.

It is worth noting that during the final month of the study, many operational changes in both reactors were implemented. During this period, the effluent arsenic concentration in both reactors decreased to less than 1 mg/L with no increase in ferric chloride dose. Summaries of influent and effluent data for the whole study were presented on Figures 5.13 and 5.14 for SBR1 and SBR2, respectively. These data suggest that a 40 mg/L dose of ferric chloride can consistently achieve an effluent arsenic concentration of less than 1 mg/L with influent arsenic concentrations of less than 11 mg/L.

5.6.4 TCLP TESTING OF SLUDGE FROM PRE-TREATMENT AND FROM BIOLOGICAL TREATMENT WITH FERRIC CHLORIDE ADDITION

To determine the quality of the solid wastes generated during the study TCLP, tests were conducted on the following samples:

- sludges generated during pre-treatment;
- sludges generated during biological treatment with ferric chloride addition; and
- filter cake and filtrate from filtration tests.

The sludge samples from the groundwater pre-treatment batches were combined to create a single composite sample and kept in a closed plastic container at 5°C and air-dried before TCLP testing.

The sample of biological sludge was a composite of wasted sludges collected from both reactors during two months of operation (September and October) when ferric chloride addition was implemented. The sludges were filtered, air-dried and kept in a closed plastic container at 5°C. A sample of biological sludge without ferric chloride addition was not collected for TCLP analyses.

A filter cake sample, generated from the sludges left in both reactors at the end of the study, was subjected to filtration tests conducted by Komline-Sanderson, a manufacturer of sludge treatment equipment, at its testing laboratory in Brampton, Ontario.

Results of TCLP testing are presented in Table 5.30. They indicate that arsenic was the only parameter that exceeded the US EPA RCRA hazardous waste characteristic concentrations (5 mg/L arsenic) for all investigated samples:

- sludge after pre-treatment : 14 mg/L
- biological sludge: 6.8 mg/L
- filter cake: 5.9 mg/L

5.6.5 TESTS ON ARSENIC REMOVAL FROM THE EFFLUENT

This section presents the results of testing to reduce the concentration of arsenic in the reactor effluent after separation from the mixed liquor. Two effluent arsenic concentrations were tested, 5.3 mg/l and 2.6 mg/l.

Results of the initial precipitation tests on the effluent indicated that the addition of iron salts, in doses up to 100 mg/L resulted in only partial removal of arsenic from the effluent (60 percent from SBR1 effluent and 23 percent from SBR2 effluent). The results of these tests are presented in Table 5.31.

During the next tests, Fenton's reagent was used. The first set of tests was conducted using the procedure previously applied for the groundwater pre-treatment. The procedure involves an addition of humates to the water before Fenton's reagent addition and it was conducted at neutral pH. The results of this procedure were presented in Table 5.32.

This procedure, which was successfully applied to the raw groundwater was not as effective for the biological effluent. The reason is probably the different speciation of arsenic in the biological effluent as compared to the raw groundwater. The removal of arsenic from the SBR1 effluent was up to 70 percent and for the SBR2 effluent only 38 percent. The final concentration of arsenic after treatment was 1.6 mg/L.

The next tests with Fenton's reagent were conducted without humates at pH = 3.5. Under these conditions, Fenton's reagent produces hydroxyl free radicals, a very powerful oxidant. The removal of arsenic during these tests was substantially better and the final concentration of arsenic was 0.4 mg/L for SBR1 effluent and 0.3 mg/L for SBR2 effluent. Results of Fenton' reagent treatment are also presented in Table 5.32.

Tests with activated alumina adsorption were conducted using AAFS-50 activated alumina product supplied by Alcan Chemicals, Brockville, Ontario. This product is recommended for arsenic removal from drinking water.

Tests were conducted with various doses of activated alumina which were mixed for 30 minutes with the same volume (100 mL) of biological treatment effluent. Results of these tests, presented in Table 5.33, indicate that a substantial amount of activated alumina (>1200 mg/L) is required to reduce the arsenic concentration below 1 mg/L.

Based on the results of tests on arsenic removal from biological effluent, Fenton's reagent treatment at pH = 3.5 seems to be the most effective post-biological treatment option. However, it is only slightly more effective than adding 40 mg/L ferric chloride during biological treatment when Fenton's reagent is applied at doses of 60 mg/L ferric sulfate and 100 mg/L hydrogen peroxide.

6.0 SUMMARY AND CONCLUSIONS

This study successfully demonstrated that complete and consistent nitrification could be achieved along with removal of organics, phenols, thiocyanate, and arsenic from representative groundwater from the WCP site. After complete and sustained nitrification was achieved, multiple experiments were undertaken to evaluate SBR operating parameters to optimize the capital and operating costs of a full scale system (i.e., HRT, temperature, arsenic treatment method). Specific conclusions of this study are presented below.

6.1 BIOLOGICAL TREATMENT

a. Biological treatment was able to effectively reduce the concentrations of ammonia, phenol, thiocyanate, and cyanide by greater than 90%.

b. This treatment efficiency was achieved with a hydraulic retention time (HRT) as low as 3 days and at a temperature as low as 19°C.

c. Effective treatment was achieved in the SBR with 3 reactor feeding cycles per day including a 1 hour FILL period during each cycle.

d. The acclimated biomass using a 3 day HRT and a 1 hour FILL is very robust. The biomass can experience a transient ammonia concentration in excess of 50 mg/L in the SBR and still achieve complete nitrification (i.e., >99% conversion of ammonia to nitrate) within a single 8 hour cycle.

e. The biomass is capable of denitrifying during an anoxic 1 hour FILL period.

f. Pretreatment for arsenic was not required to achieve effective biological treatment of all the other constituents in the groundwater.

6.2 ARSENIC TREATMENT

a. The biomass in the SBR was not able to sustain any significant reduction in arsenic concentration.

b. The addition of 40 mg/L ferric iron to the activated sludge was able to effectively reduce arsenic in the effluent by greater than 85%.

c. The biomass was found to exceed the TCLP limit for arsenic when arsenic was precipitated using 40 mg/L of ferric iron. The pretreatment sludge (i.e., sludge from Fenton's reagent/humic acid treatment) was also found to exceed the TCLP

limit. Biomass without iron addition will accumulate arsenic but was not tested using TCLP during the study.

d. The SBR effluent is amenable to arsenic treatment using Fenton's reagent at a pH of 3.5 or absorption using activated alumina.

e. Some of the arsenic is lost to the air above the SBR due to volatilization during aeration in the SBRs.

6.3 PROCESS CONTROL

a. Ammonia conversion to nitrate (nitrification) is the limiting treatment process. Once ammonia concentrations have reached less than 1 mg/L the biomass is endogenously respiring (i.e., bacteria are no longer degrading contaminants).

b. Dissolved oxygen concentration (DO) was found to be an important process control parameter. The DO profile during the SBR cycle was able to show the end of nitrification. The DO profile, shape and time to reach endogenous respiration (DO recovery), was also a good indicator of the overall health of the biomass. During upset recovery, evaluation of the shape of the DO profile and time to achieve DO recovery provided a good indication of whether the biomass was ready to treat additional feed.

c. Reactor operation requires addition of a base to neutralize the nitric acid produced during nitrification. Caustic is recommended for pH control in the full scale system.

d. Reactor operation requires PAC addition and sludge wasting to maintain MLTSS around 8,000 mg/L.

6.4 BIOMASS ACCLIMATIZATION

a. The effective acclimatization procedure requires 6 cycles per day with a 1 hour FILL while slowly increasing the ammonia loading. Acclimatization was successful with a 7.5 day HRT.

b. Once a 5 day HRT is achieved, the number of cycles per day can be reduced to 3 while maintaining a 1 hour FILL.

c. Once 3 cycles with 1 hour FILL is reached, the HRT can be reduced to 3 days.

6.5 UPSET RECOVERY

a. Acclimatized biomass can be recovered (i.e., <1 mg/L of ammonia in effluent) from a complete upset of nitrification (i.e., no ammonia degradation) in 3 days. Recovery to pre-upset biokinetic conditions may take up to 9 days.

b. The upset recovery procedure requires sludge washing followed by seeding the upset reactor from a normally running reactor.

6.6 DESIGN BASIS

A schematic of the proposal treatment system is presented on Figure 6.1. The treatment system will consist of the following major components:

1)	An equalization tank	- HRT ~1 day - mechanical mixers - mechanism to collect and remove solids - phosphoric acid storage and addition mechanism
2)	Three SBRs	- HRT = 5 days - mechanical mixer - aeration system - pH controller - heaters - decant mechanism - sludge pump - ferric chloride addition for arsenic treatment - covered and under low suction vacuum
3)	Holding Tank	- HRT ~1/2 day - provision for sample collection - provision to return reject water to influent equalization tank

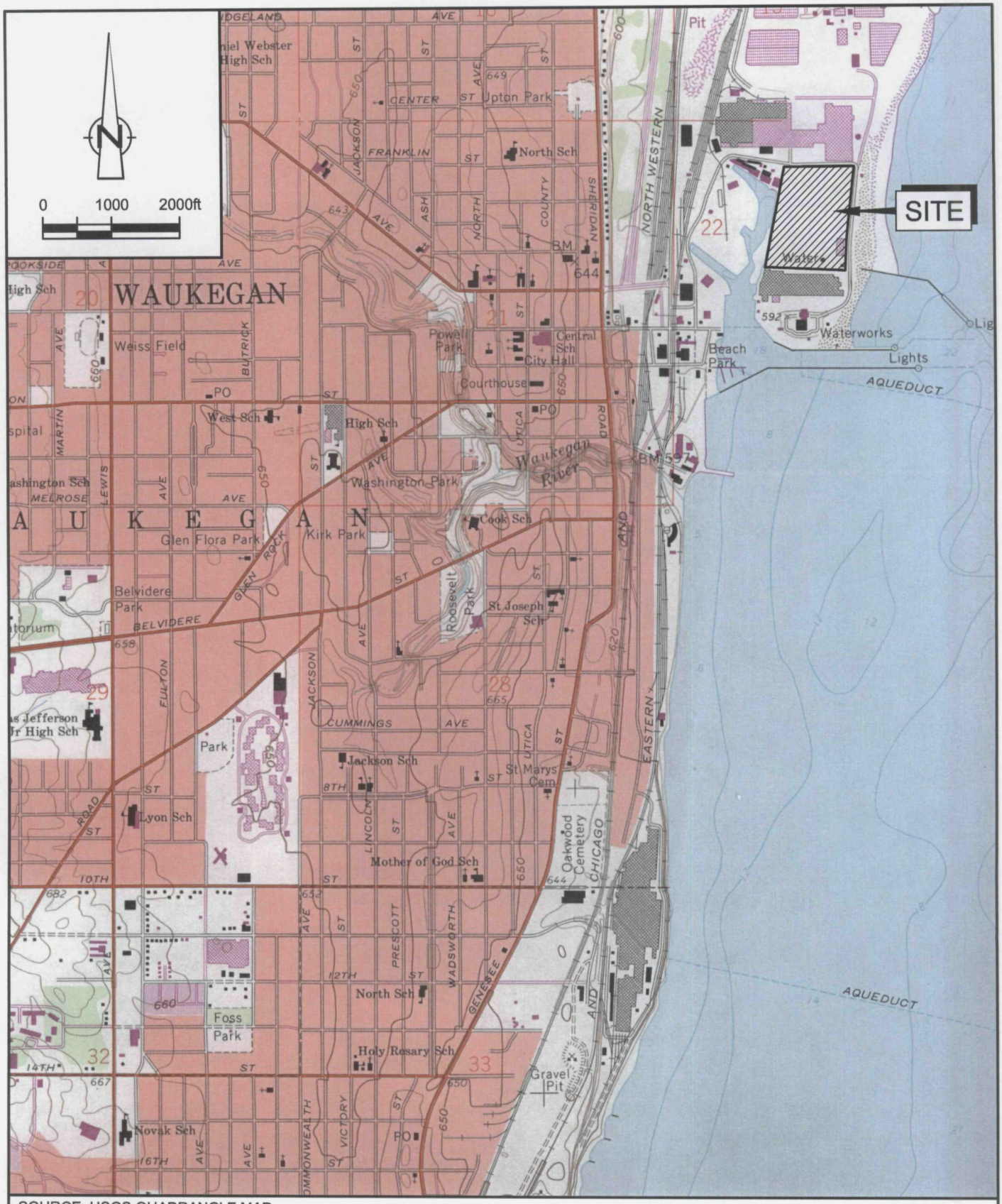
4)	Equalization Tank	- HRT ~1 day - storage to provide operational flexibility to re-injection
5)	Sludge Management System	- holding tank - polymer addition - filter press - filtrate return - pressed sludge shipping
6)	Odor Control Systems	- may also be necessary for arsenic control

To initiate treatment operation, the SBR's will be filled with activated sludge from a coke works biological treatment plant that has been tested to confirm that the biomass has a healthy population of nitrifiers. The plant will be operated at 7 days HRT, 30°C with 5 feed cycles per day. Aeration will be maintained at all times except during settling and decant cycles. Acclimatization is expected to take up to three months. Once steady nitrification is demonstrated and biokinetics confirm an active biomass, the HRT will be gradually reduced to 3 days and the feed cycles reduced to 3 per day. A feed cycle is expected to consist of 60 minutes FILL; 260 minutes REACT; 100 minutes SETTLE; and 60 minutes DRAW. Finally, the temperature of the mixed liquids will be gradually reduced to 20°C.

After a month of satisfactory operations, feed without aeration will be initiated.

The SBR's will be operated sequentially, off set by one third of a feed cycle so that a reactor showing any distress can be bypassed for one feeding.

FIGURES

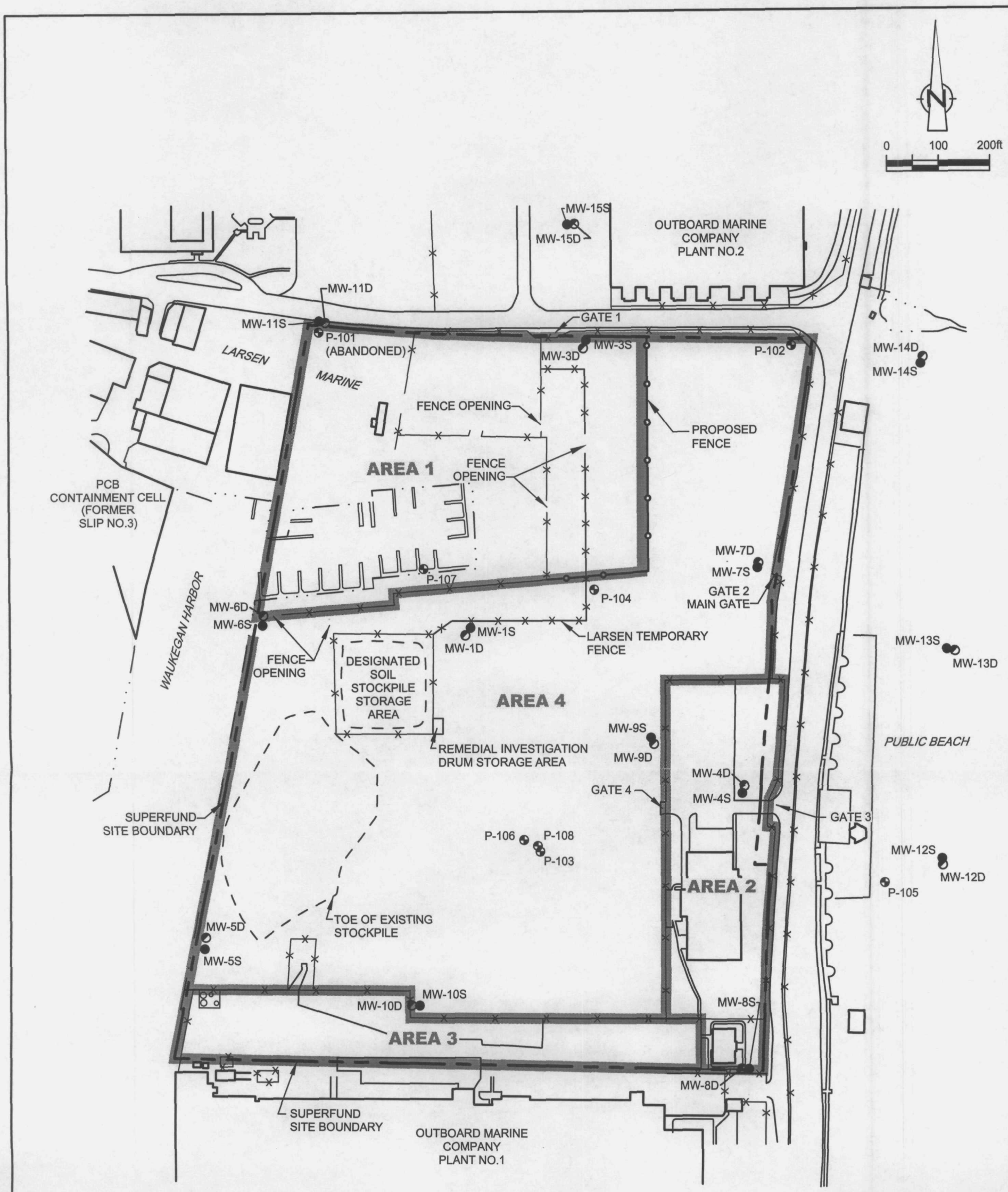


SOURCE: USGS QUADRANGLE MAP;
WAUKEGAN, ILLINOIS

figure 1.1

SITE LOCATION
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
Waukegan, Illinois

19023-23(010)GN-WA020 MAY 21/2004



LEGEND

MW-10S ●	SHALLOW MONITORING WELL LOCATION AND IDENTIFIER
MW-10D ◐	DEEP MONITORING WELL LOCATION AND IDENTIFIER
P-102 ⊕	PIEZOMETER LOCATION AND IDENTIFIER
—x—x—	SITE FENCE
x-x-x-x-x-x	LARSEN TEMPORARY FENCE
—o—o—	PROPOSED FENCE

NOTE:
FENCE LINE AND GATE LOCATIONS ARE APPROXIMATE

figure 1.2

SITE PLAN
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA021 MAY 21/2004

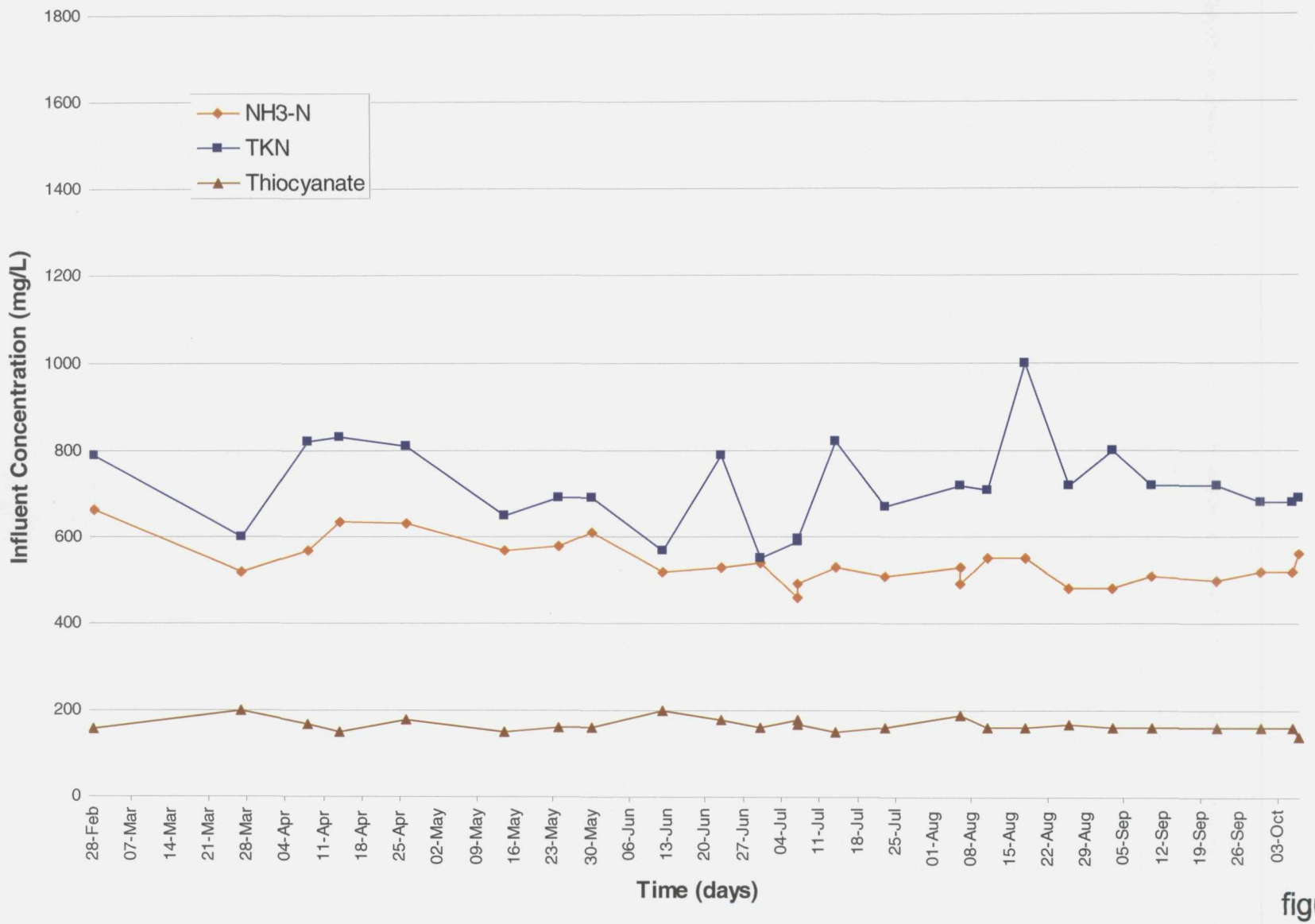


figure 2.1

SUMMARY OF RAW GROUNDWATER DATA
NH3-N, TKN, THIOCYANATE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA028 MAY 21/2004

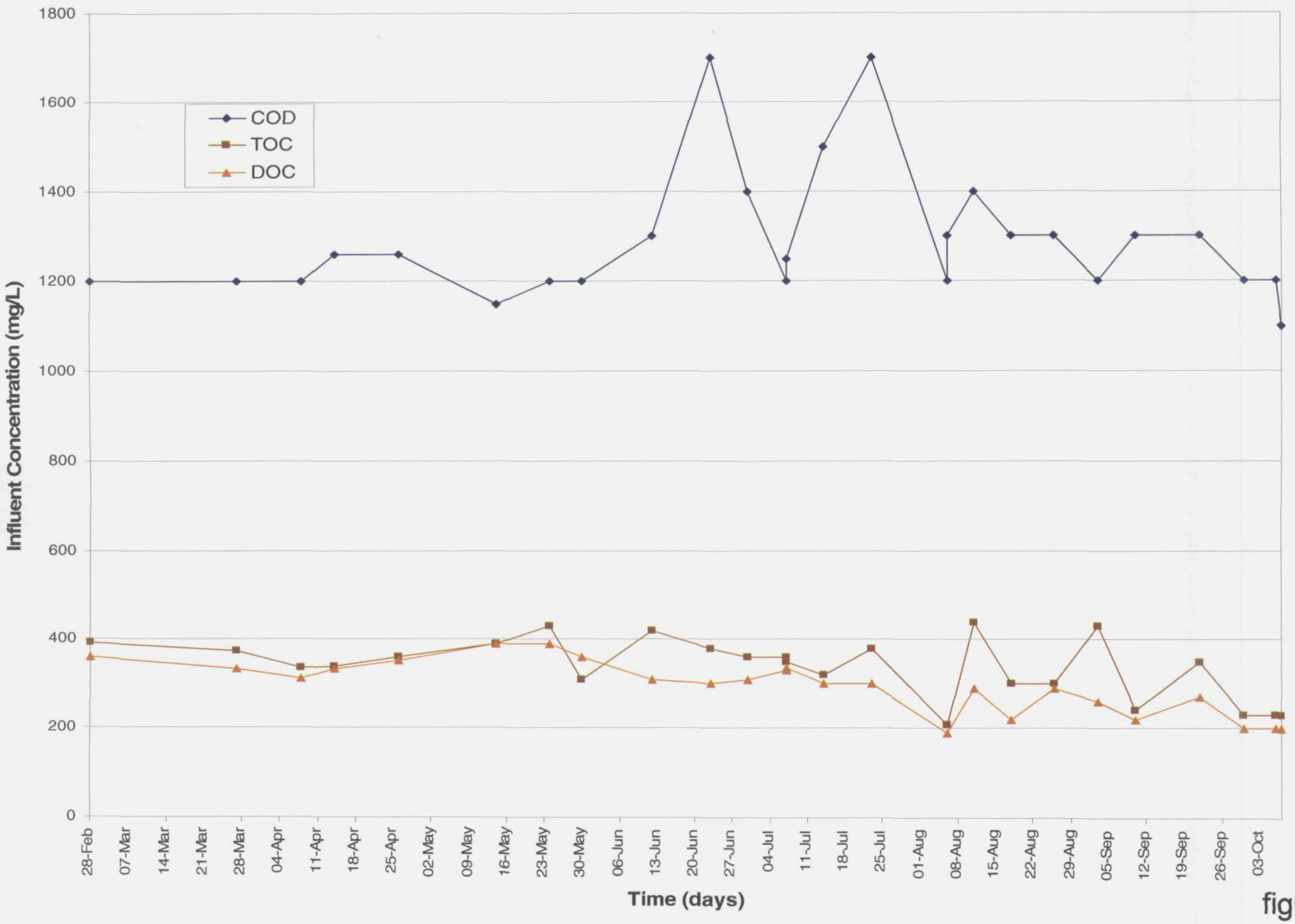


figure 2.2

SUMMARY OF RAW GROUNDWATER DATA
COD, TOC, DOC
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA029 MAY 21/2004

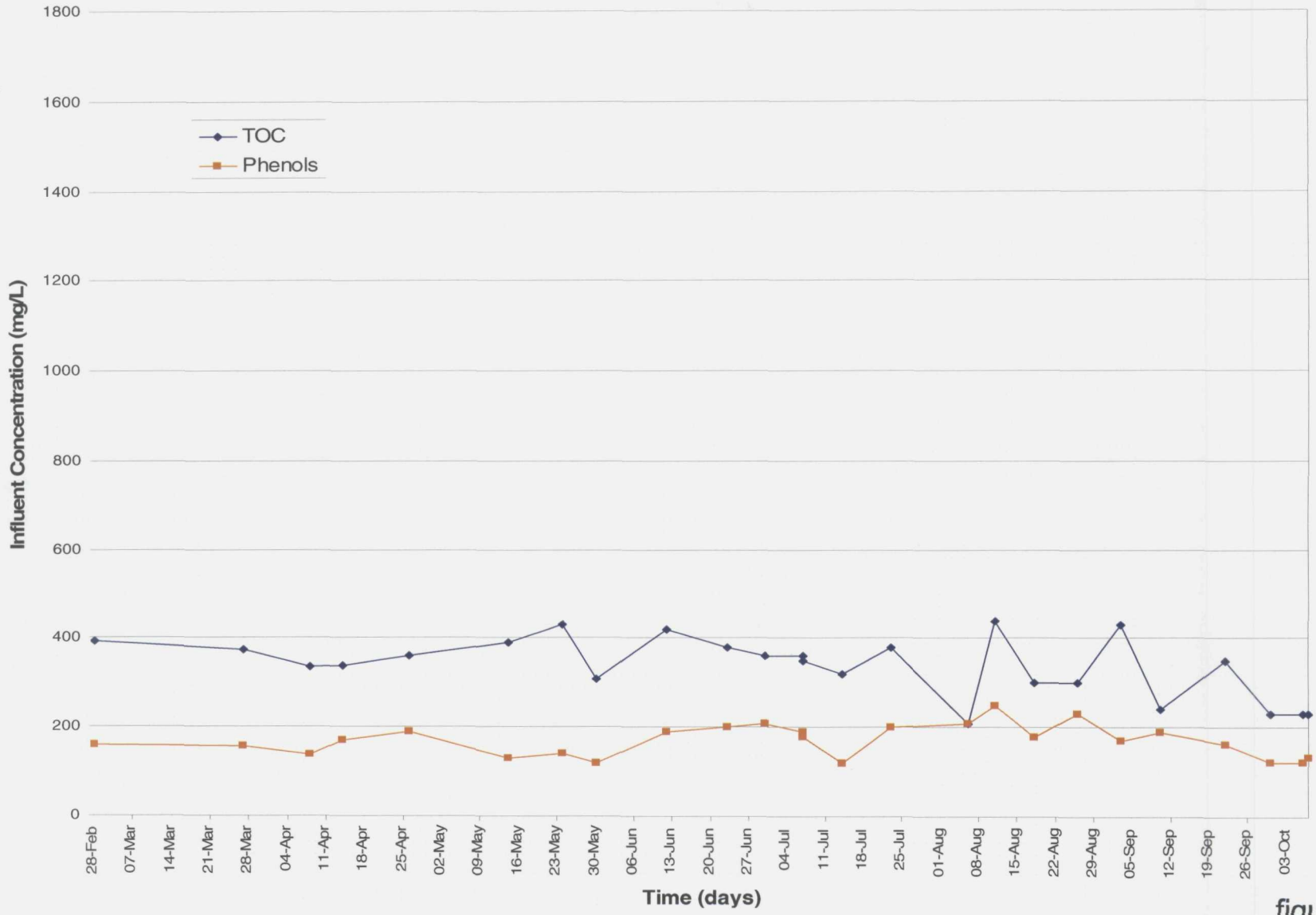


figure 2.3

SUMMARY OF RAW GROUNDWATER DATA
TOC, PHENOLS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA030 MAY 21/2004

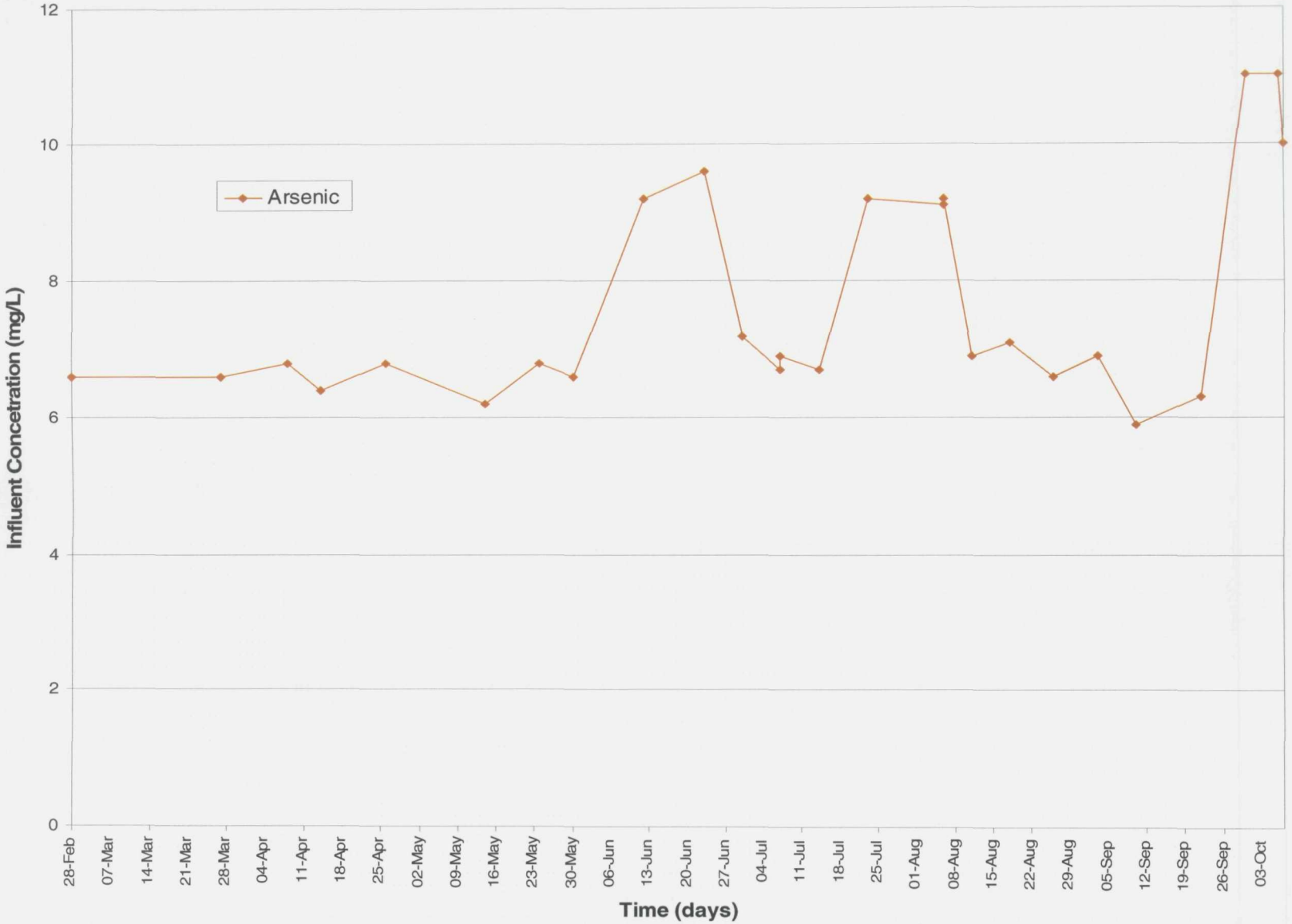


figure 2.4

SUMMARY OF RAW GROUNDWATER DATA
ARSENIC
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA031 MAY 21/2004

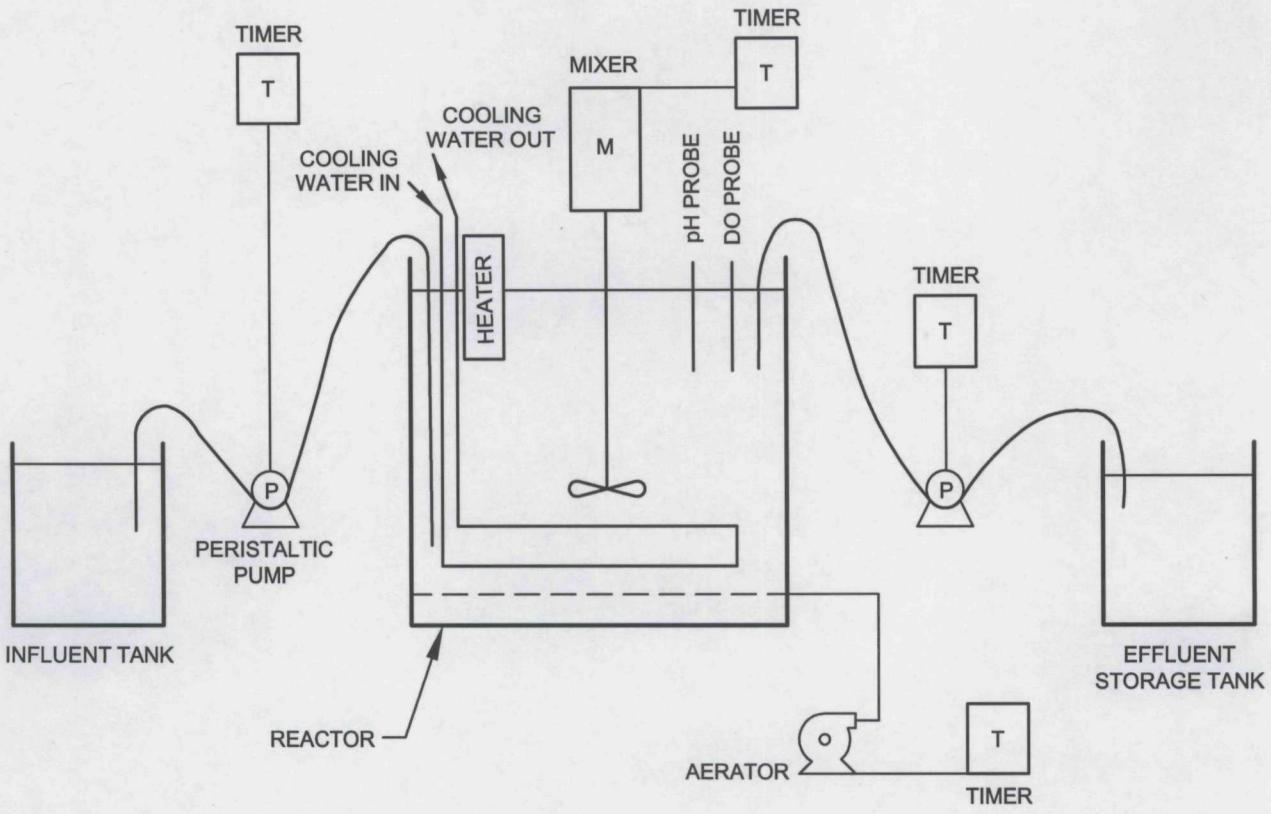


figure 4.1

BATCH TREATMENT SYSTEM SCHEMATIC
NITRIFICATION STUDY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

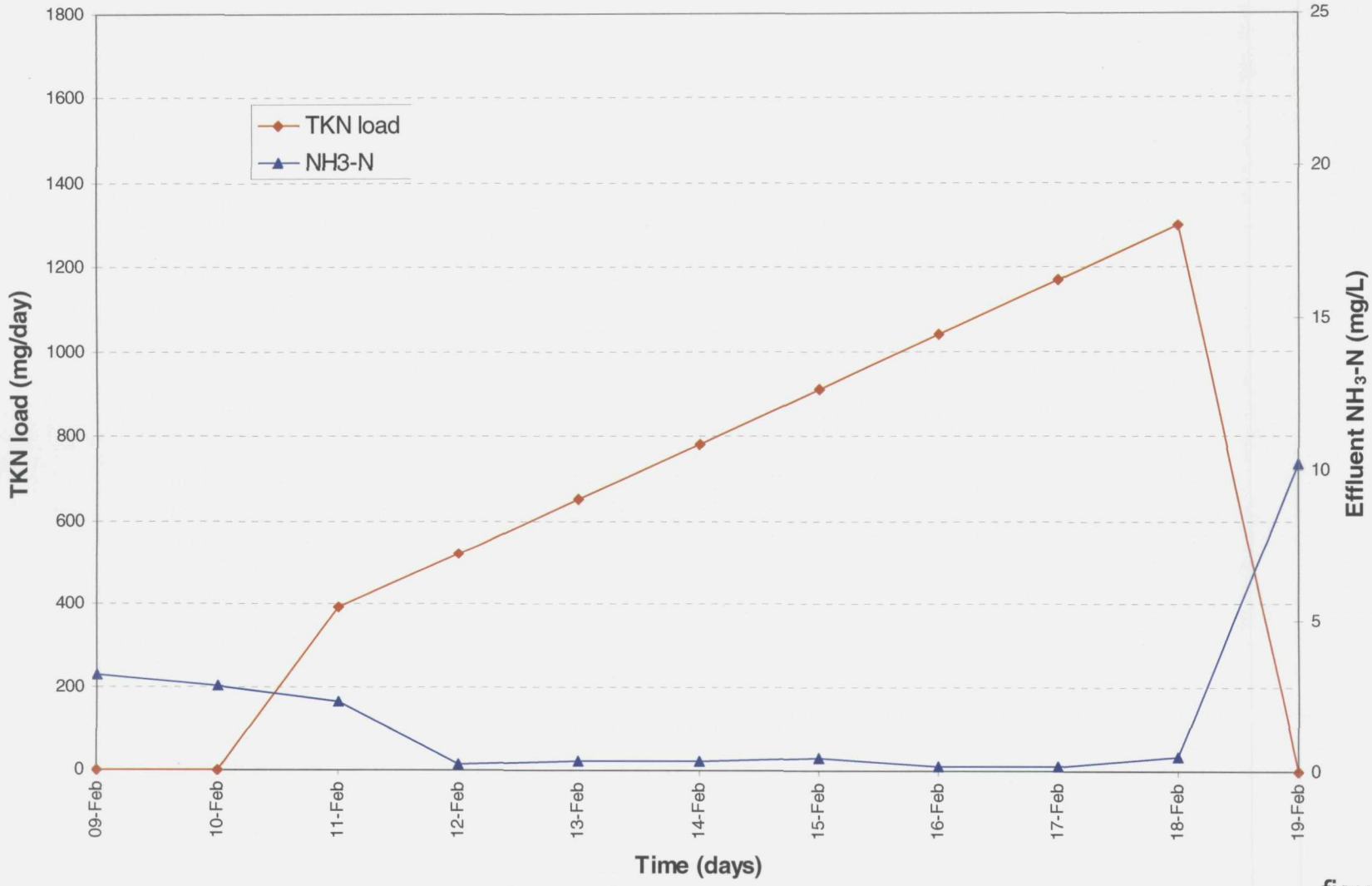


figure 5.1

ACCLIMATIZATION OF SBR 1
FEBRUARY 9 - FEBRUARY 19
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA022 MAY 21/2004

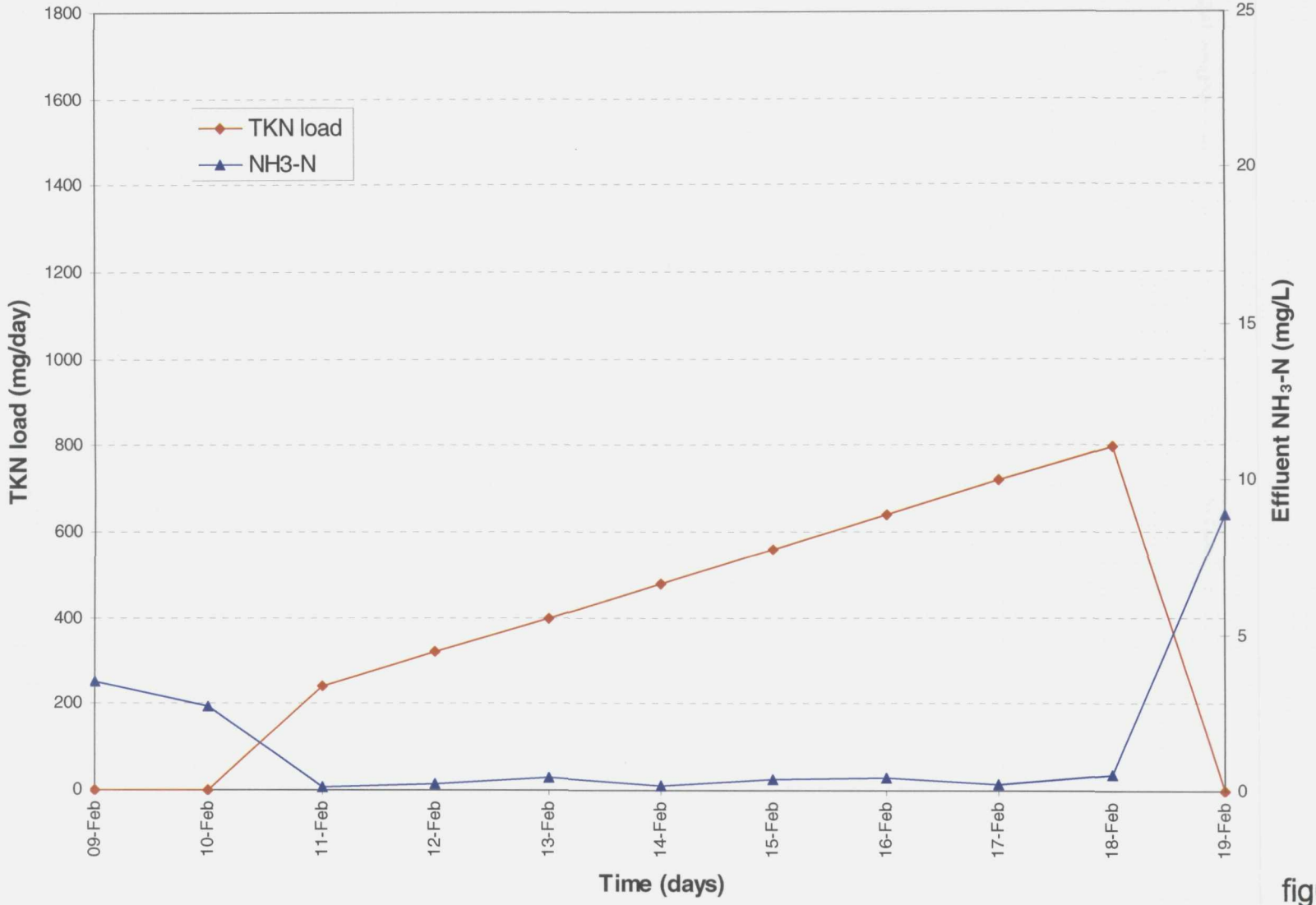


figure 5.2

ACCLIMATIZATION OF SBR 2
FEBRUARY 9 - FEBRUARY 19
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA023 MAY 21/2004

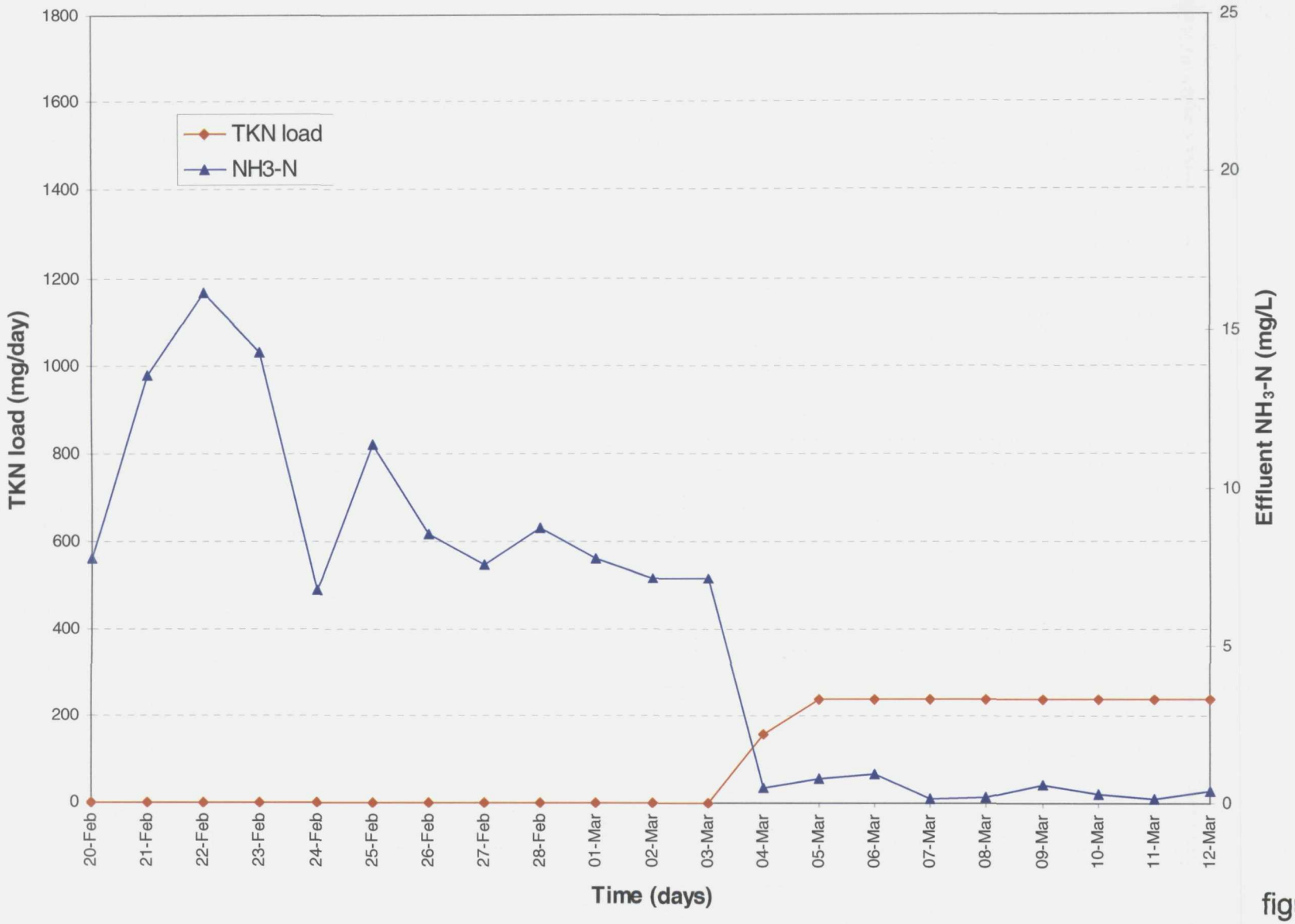


figure 5.3

ACCLIMATIZATION OF SBR 1
FEBRUARY 20 TO MARCH 12
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA024 MAY 21/2004

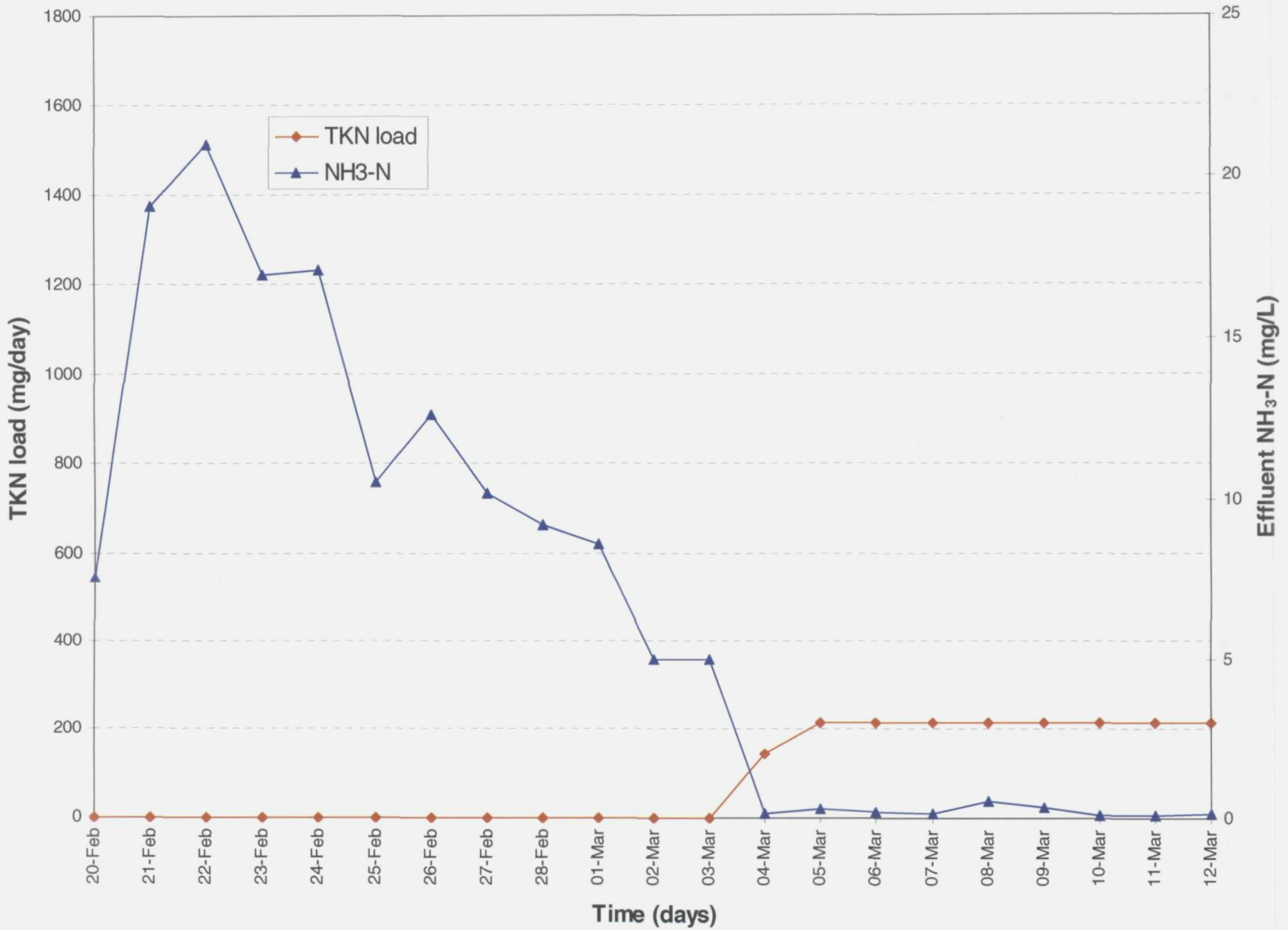


figure 5.4

ACCLIMATIZATION OF SBR 2
FEBRUARY 20 TO MARCH 12
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA025 MAY 21/2004

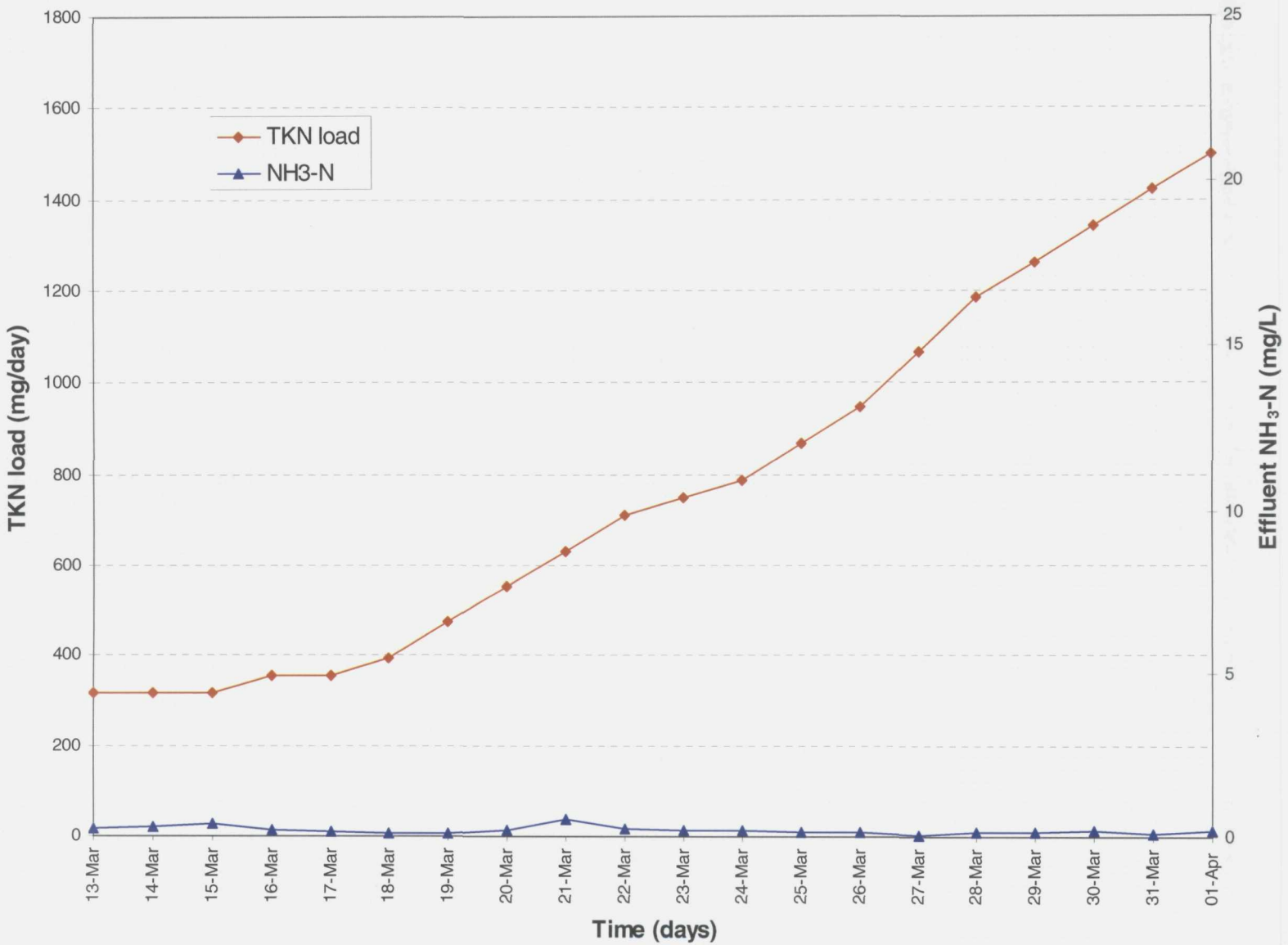


figure 5.5

ACCLIMATIZATION OF SBR 1
MARCH 13 - APRIL 1
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA026 MAY 21/2004

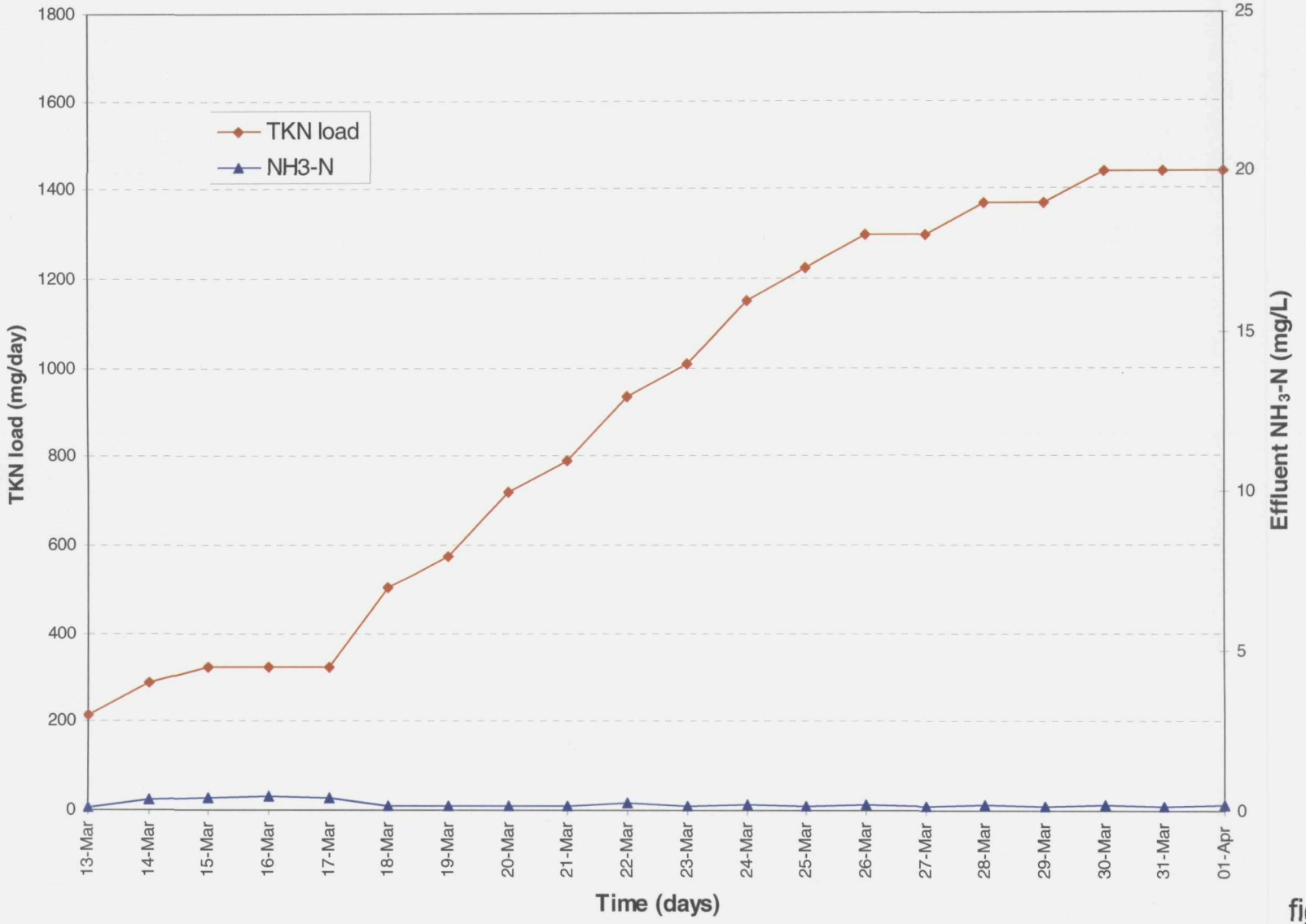


figure 5.6

ACCLIMATIZATION OF SBR2
MARCH 13 - APRIL 1
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

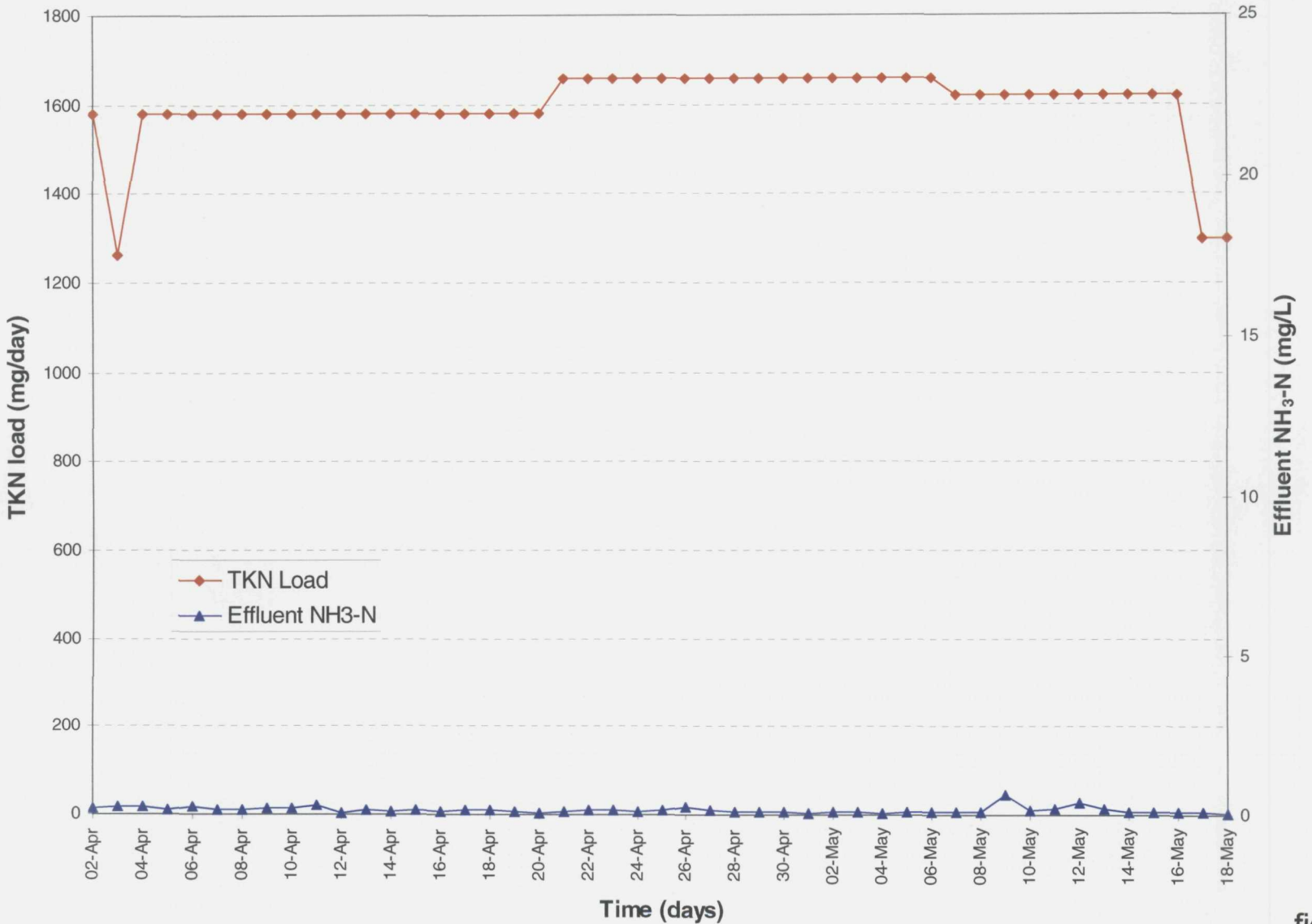


figure 5.7

STEADY STATE OPERATION OF REACTOR SBR1
RAW GROUNDWATER FEED AT 7.5 DAYS HRT AND 30° C
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

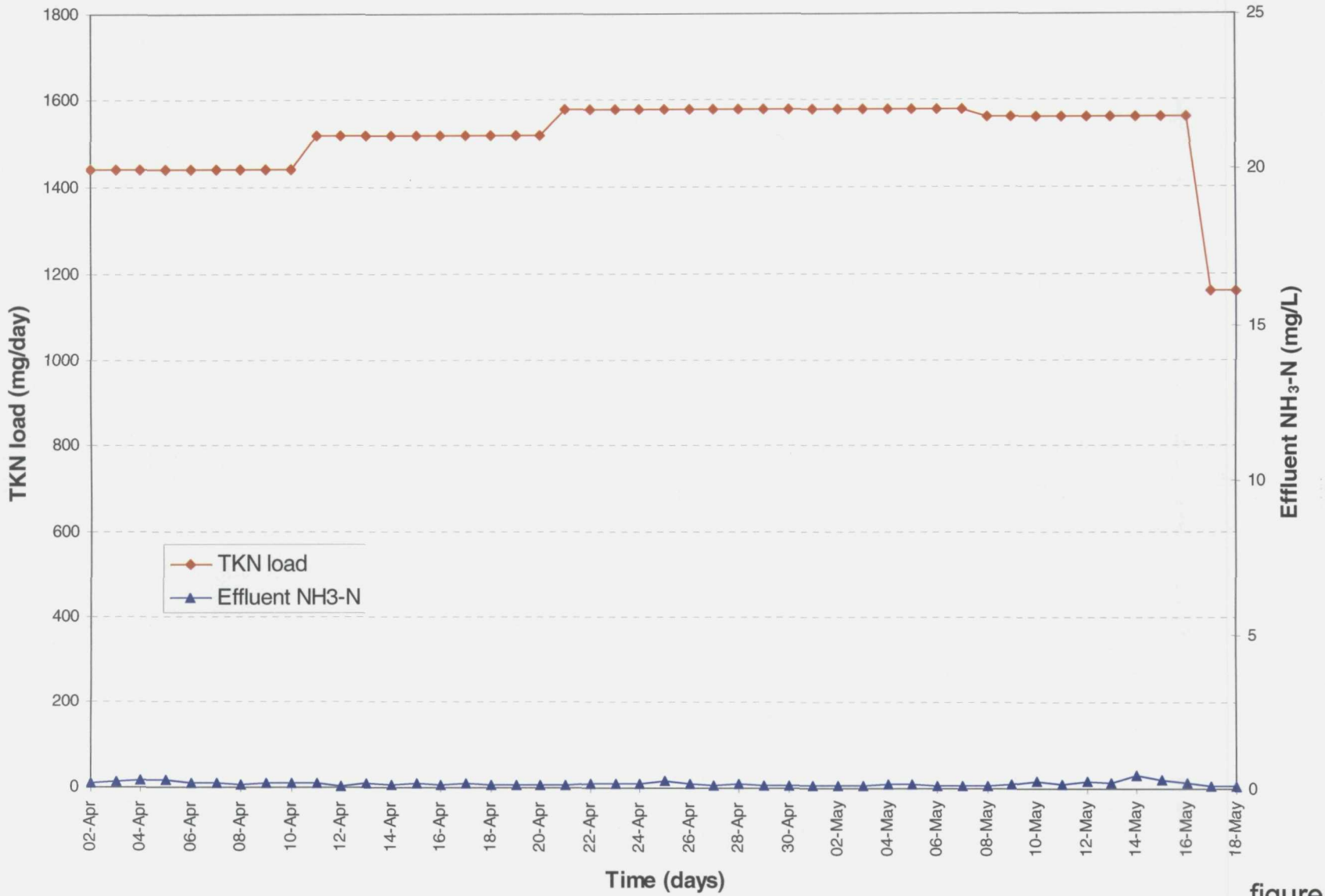


figure 5.8

STEADY STATE OPERATION OF SBR2
PRE-TREATED GROUNDWATER FEED AT 7.5 DAYS HRT AND 30° C
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

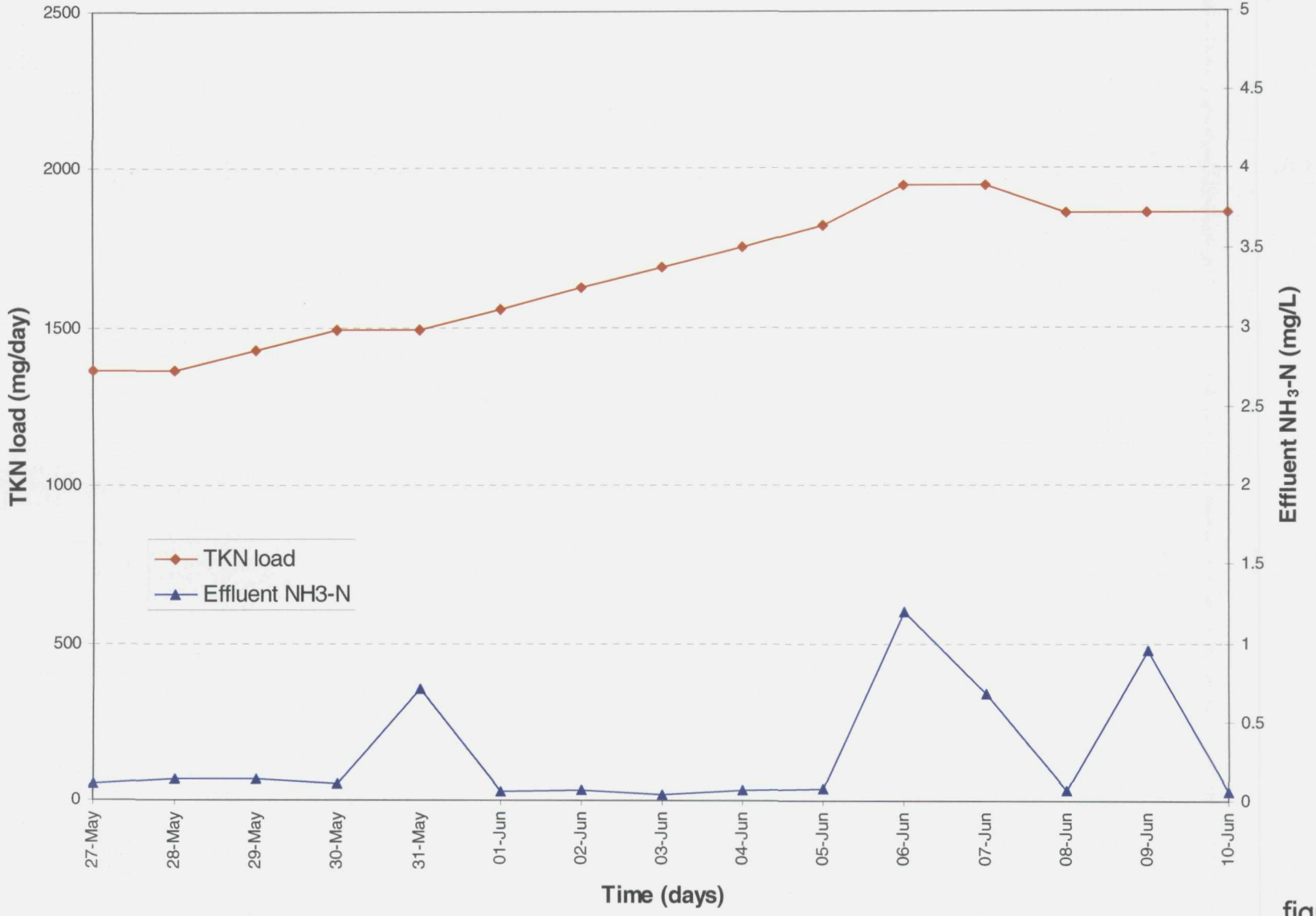


figure 5.9

OPTIMIZATION OF SBR1
5 DAYS HRT 30°C AND PROLONGED FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA040 MAY 21/2004

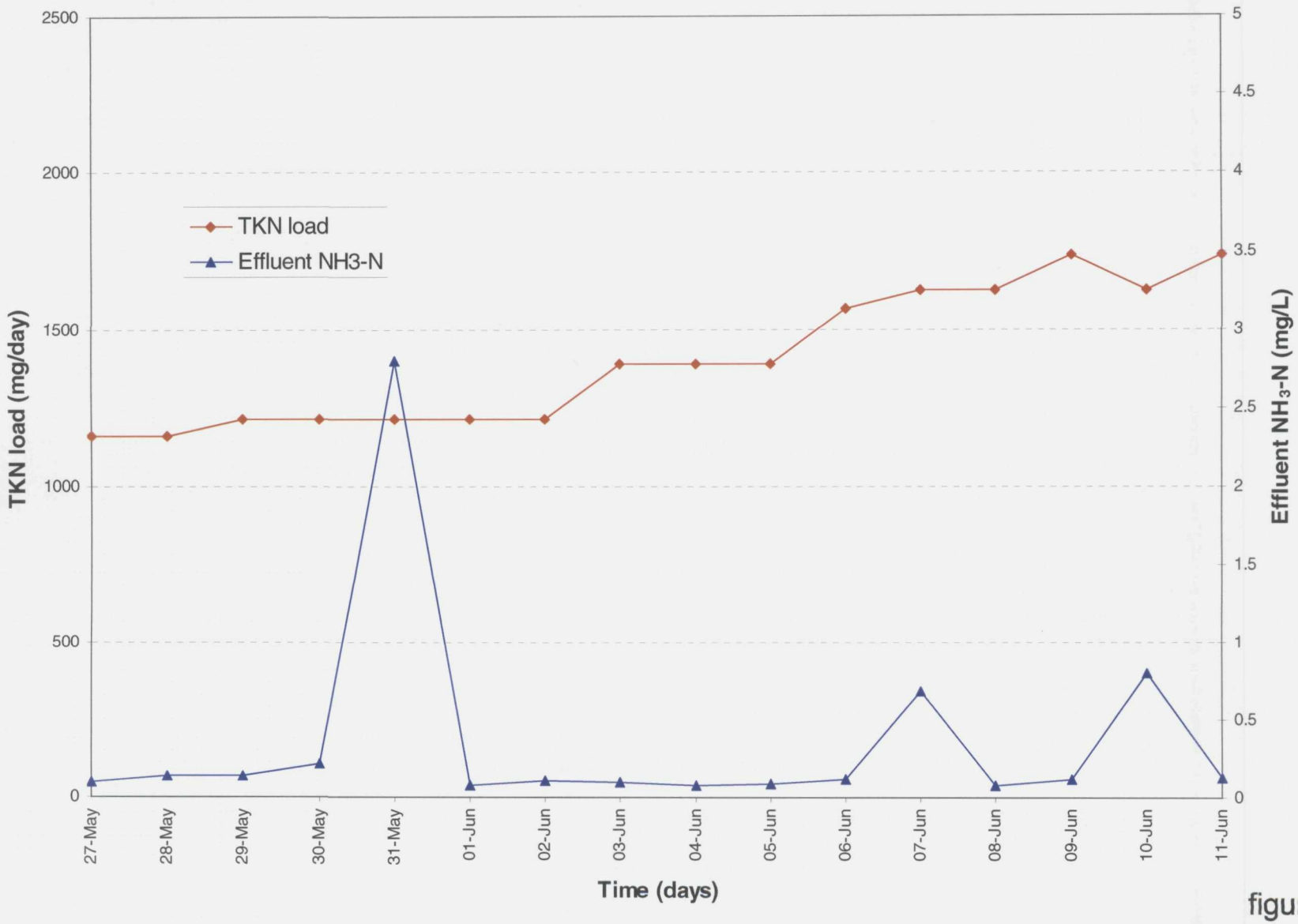


figure 5.10

OPTIMIZATION OF SBR2
5 DAYS HRT 30°C AND PROLONGED FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA041 MAY 21/2004

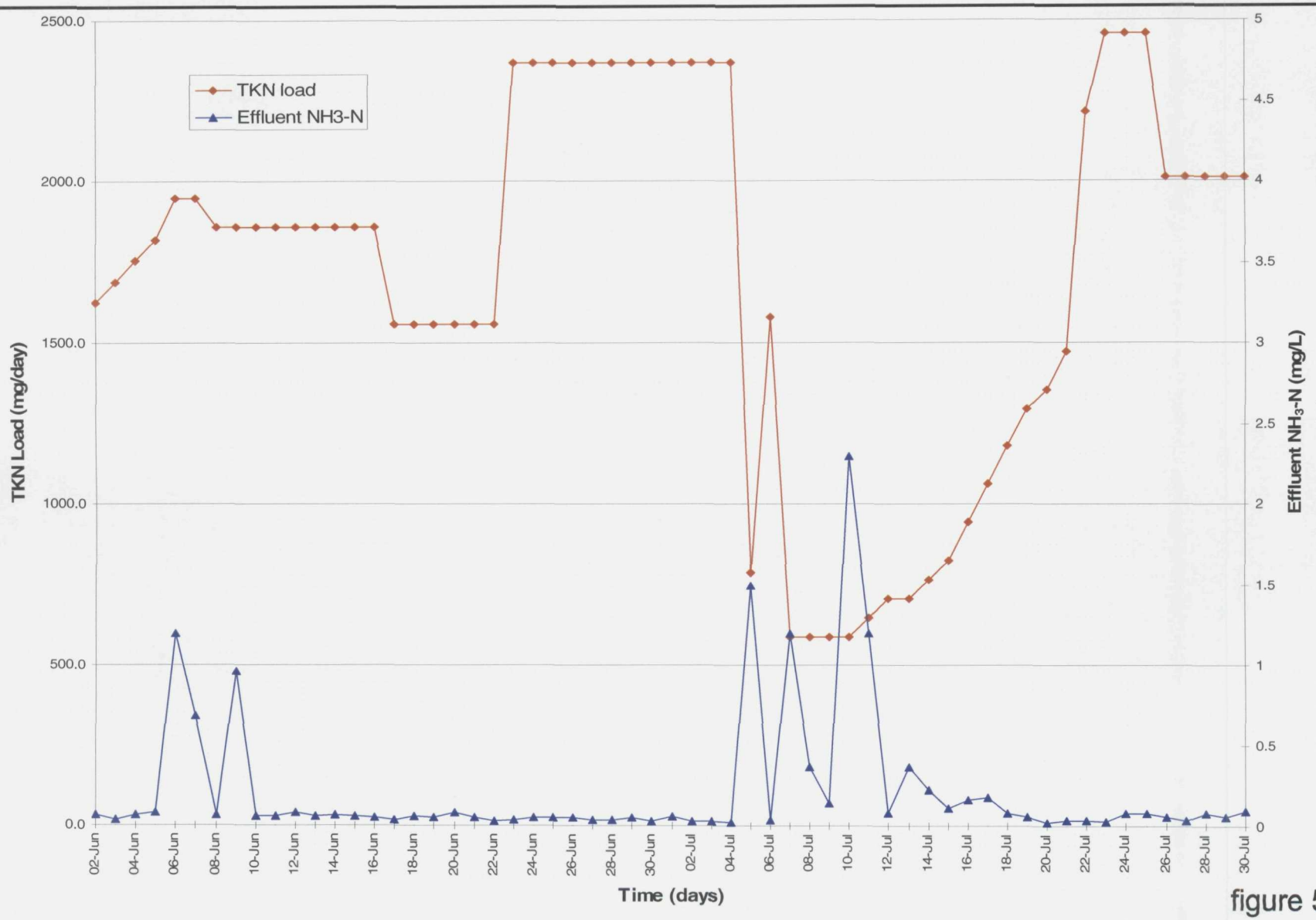


figure 5.11

OPTIMIZATION OF SBR1
5 DAYS HRT 30°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

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19023-23(010)GN-WA032 MAY 21/2004

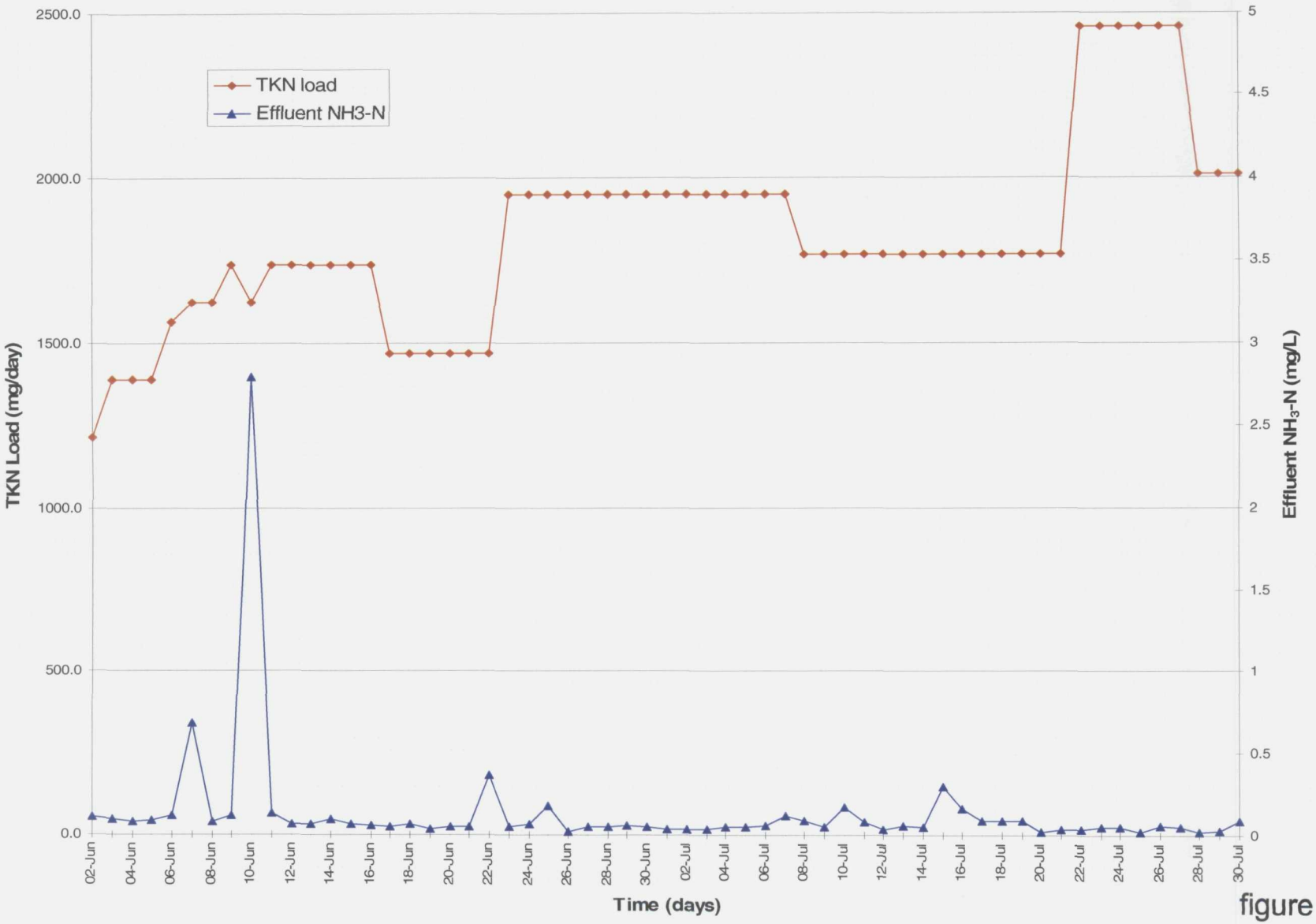

figure 5.12

OPTIMIZATION OF SBR2
5 DAYS HRT 25°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA033 MAY 21/2004

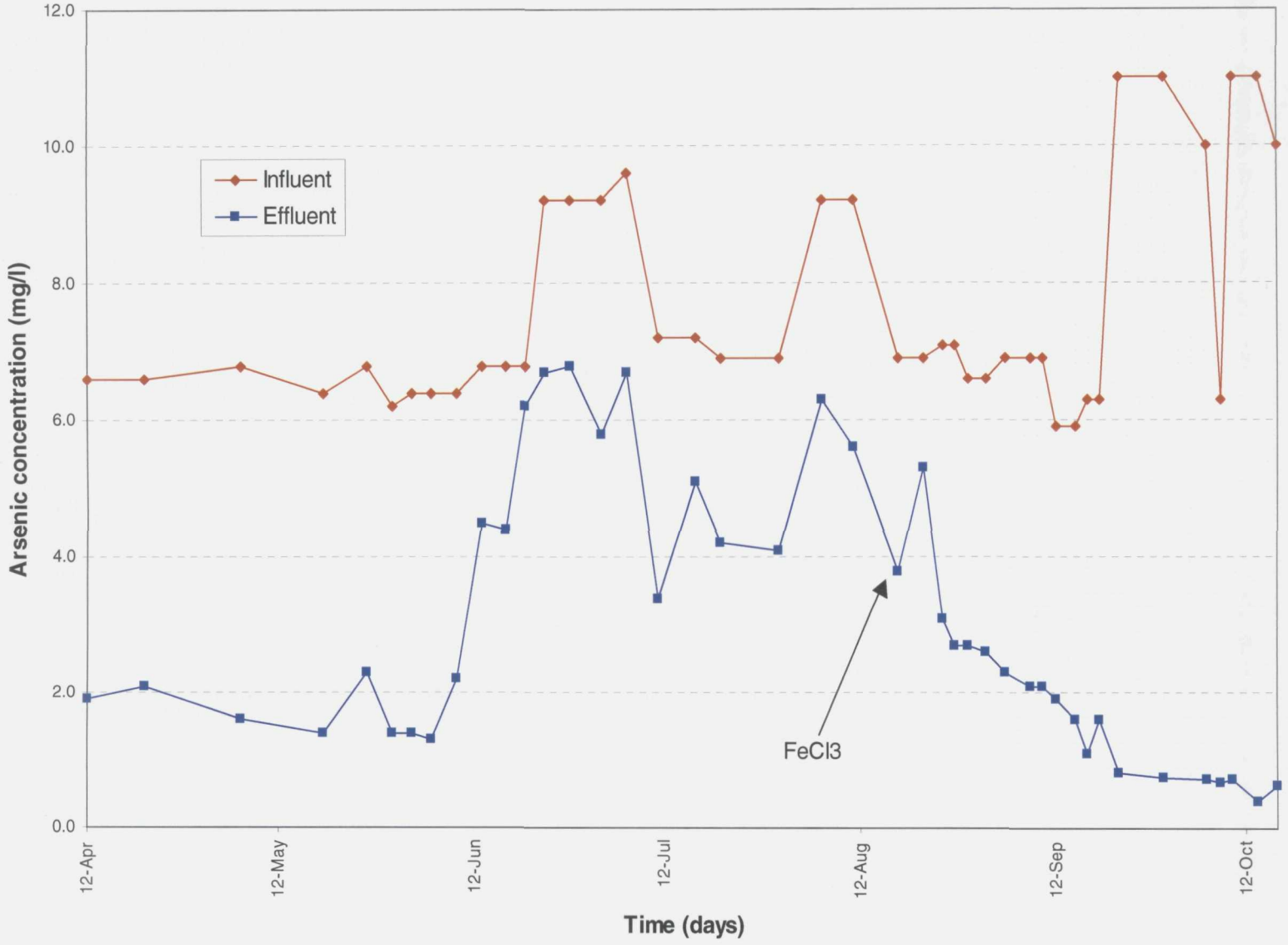

figure 5.13

ARSENIC IN THE INFLUENT AND EFFLUENT OF SBR1
RAW GROUNDWATER FEED WITHOUT FERRIC CHLORIDE ADDITION
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

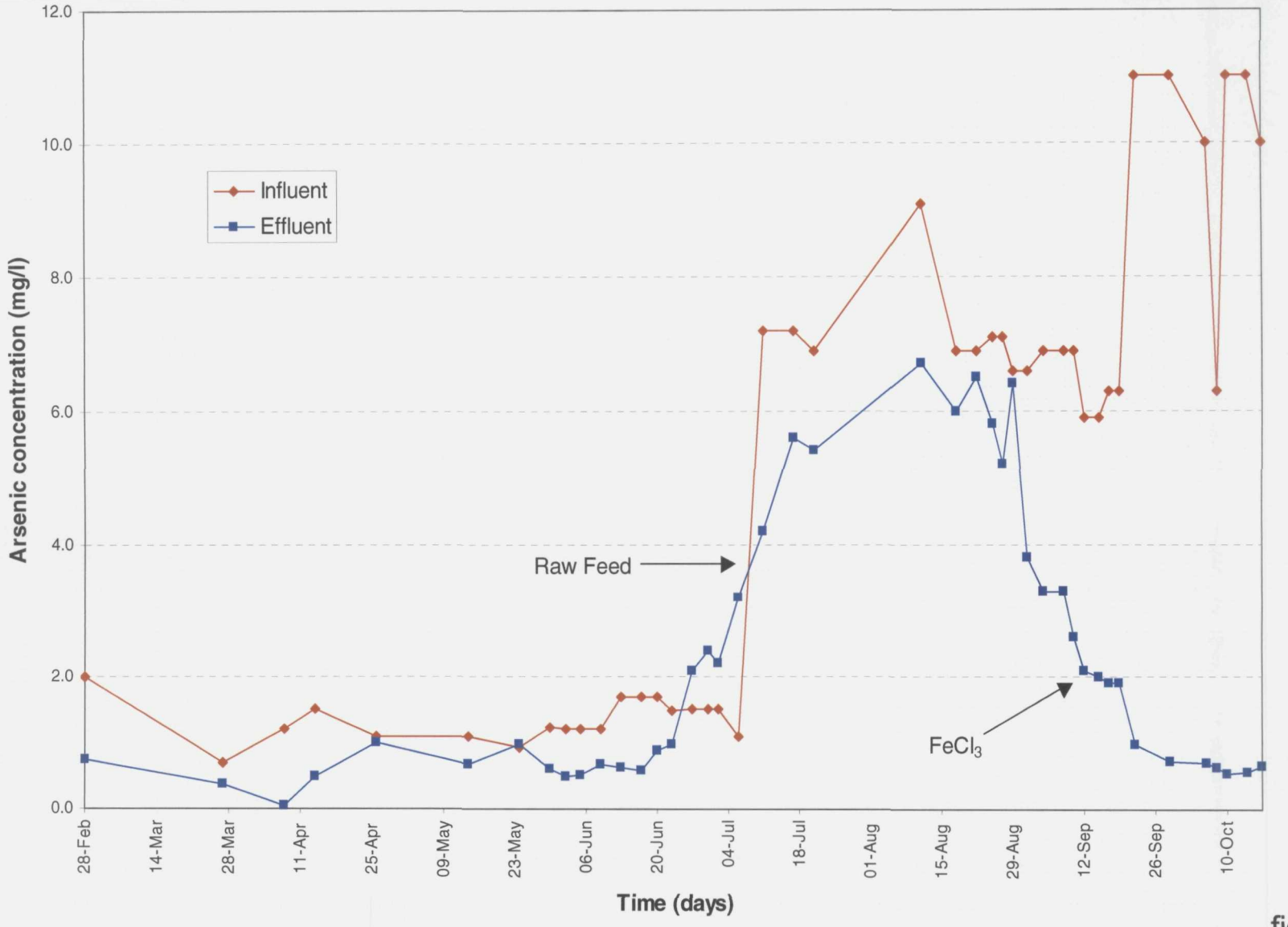

figure 5.14

ARSENIC IN THE INFLUENT AND EFFLUENT OF SBR2
PRE-TREATED GROUNDWATER FEED WITHOUT FERRIC CHLORIDE ADDITION
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

19023-23(010)GN-WA035 MAY 21/2004

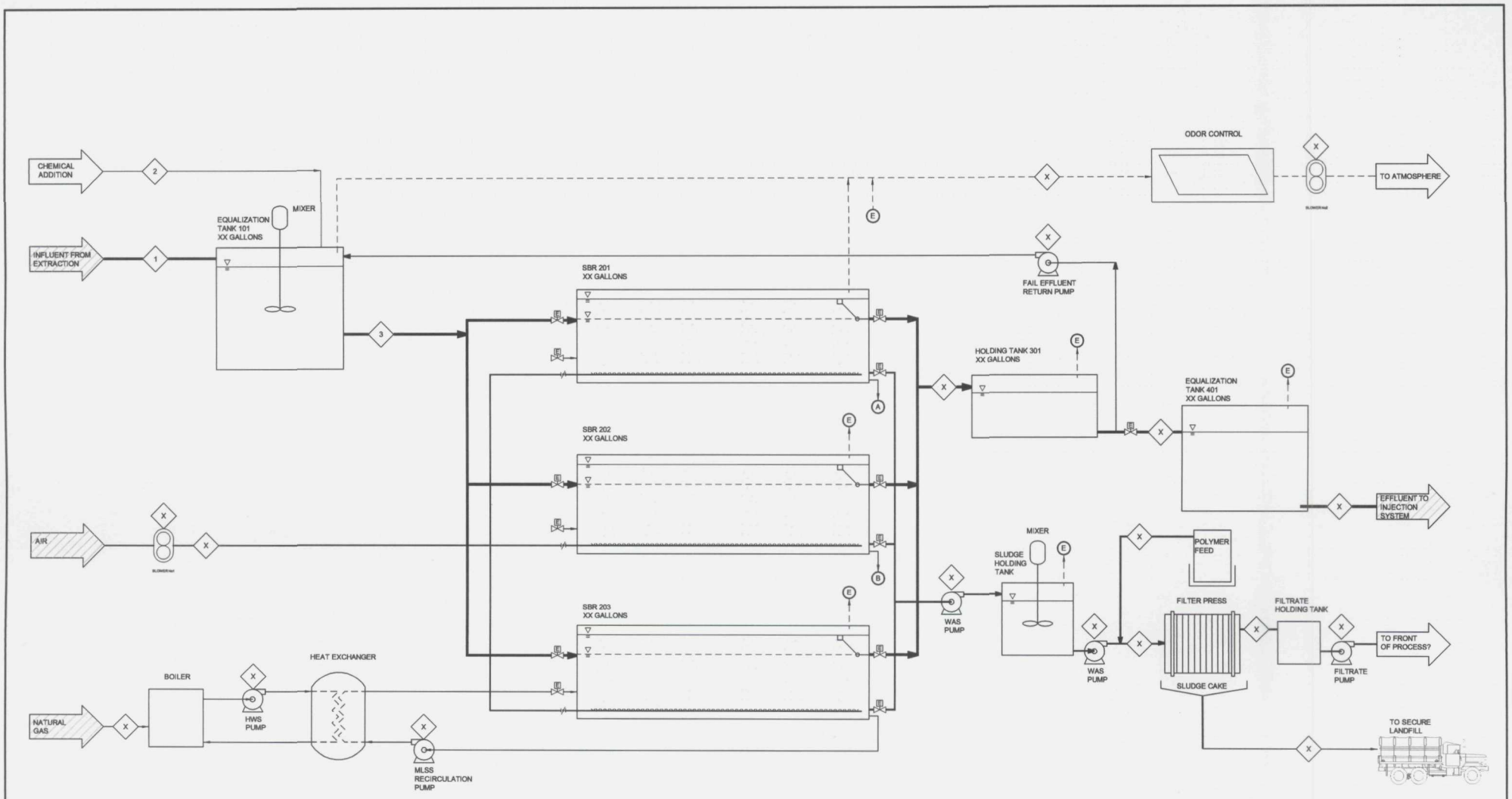

figure 6.1

GROUNDWATER TREATMENT
PLANT PROCESS FLOW DIAGRAM
WAUKEGAN GAS AND COKE PLANT
Waukegan, Illinois

19023-23(010)GN-WA046 MAY 21/2004

TABLES

TABLE 2.1

ANALYTICAL DATA FOR GROUNDWATER COMPOSITE (BATCHES) USED IN NITRIFICATION STUDY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date of preparation	*Parameter (mg/L)*													
	pH (st Units)	*NH_3-N*	*TKN*	*NO_3-N*	*COD*	*TOC*	*DOC*	*Phenols*	*Thiocyanate*	*Total Cyanide*	*TSS*	*VSS*	*Arsenic*	*Sulfate*
2/28/2003	8.10	662.0	790.0	<2	1200.0	392.0	360.0	160.0	158.0	2.4	3.0	2.0	6.6	130
3/27/2003	8.20	521.0	600.0	<1	1200.0	374.0	333.0	158.0	200.0	3.6	2.3	2.0	6.6	140
4/8/2003	8.00	568.0	820.0	<1	1200.0	337.0	313.0	138.0	170.0	3.5	8.0	7.0	6.8	120
4/14/2003	8.00	634.0	830.0	<1	1260.0	338.0	333.0	170.0	150.0	3.5	6.0	3.0	6.4	130
4/26/2003	8.10	630.0	810.0	<1	1260.0	360.0	353.0	190.0	180.0	3.7	6.0	5.0	6.8	135
5/14/2003	8.20	570.0	650.0	<1	1150.0	390.0	390.0	130.0	150.0	4.7	6.0	5.0	6.2	140
5/24/2003	7.80	578.0	690.0	<1	1200.0	430.0	390.0	140.0	160.0	4.3	20.0	15.0	6.8	150
5/30/2003	7.90	610.0	690.0	<1	1200.0	310.0	360.0	120.0	160.0	3.6	20.0	13.0	6.6	130
6/12/2003	7.70	520.0	570.0	<1	1300.0	420.0	310.0	190.0	200.0	3.8	20.0	15.0	9.2	130
6/23/2003	8.10	530.0	790.0	2.1	1700.0	380.0	300.0	200.0	180.0	3.2	104.0	65.0	9.6	130
6/30/2003	7.90	540.0	550.0	0.5	1400.0	360.0	310.0	210.0	160.0	3.1	20.0	16.0	7.2	140
7/7/2003	8.00	460.0	590.0	0.5	1200.0	360.0	330.0	190.0	180.0	2.9	39.0	25.0	6.7	145
7/7/2003	8.20	490.0	596.0	2.0	1250.0	350.0	335.0	180.0	170.0	2.9	32.0	26.0	6.9	130
7/14/2003	8.10	530.0	820.0	2.0	1500.0	320.0	300.0	120.0	150.0	4.4	39.0	29.0	6.7	150
7/23/2003	7.90	510.0	670.0	1.2	1700.0	380.0	300.0	200.0	160.0	3.1	110.0	69.0	9.2	140
8/6/2003	7.90	530.0	720.0	0.8	1200.0	208.0	190.0	210.0	190.0	2.5	98.0	82.0	9.1	135
8/6/2003	8.00	490.0	720.0	5.0	1300.0	210.0	190.0	210.0	190.0	2.5	98.0	82.0	9.2	140
8/11/2003	8.10	550.0	710.0	0.5	1400.0	440.0	290.0	250.0	160.0	2.6	14.0	8.0	6.9	150
8/18/2003	8.10	550.0	1000.0	0.5	1300.0	300.0	220.0	180.0	160.0	2.2	25.0	18.0	7.1	140
8/26/2003	7.90	480.0	720.0	0.5	1300.0	300.0	290.0	230.0	170.0	2.8	12.0	8.0	6.6	140
9/3/2003	7.80	480.0	800.0	0.5	1200.0	430.0	260.0	170.0	160.0	3.1	26.0	21.0	6.9	130
9/10/2003	7.90	510.0	720.0	0.5	1300.0	240.0	220.0	190.0	160.0	3.8	8.0	7.0	5.9	130
9/22/2003	8.00	500.0	720.0	0.5	1300.0	350.0	270.0	162.0	160.0	2.7	14.0	12.0	6.3	140
9/22/2003	7.90	500.0	720.0	0.5	1300.0	350.0	270.0	162.0	160.0	2.7	14.0	12.0	6.3	140
9/30/2003	7.90	520.0	680.0	0.5	1200.0	230.0	200.0	122.0	160.0	4.4	46.0	32.0	11.0	140
10/6/2003	7.80	520.0	680.0	0.5	1200.0	230.0	200.0	122.0	160.0	4.4	46.0	32.0	11.0	130
10/7/2003	8.10	560.0	690.0	0.5	1100.0	230.0	200.0	132.0	140.0	3.4	35.0	28.0	10.0	140
10/7/2003	7.80	560.0	690.0	0.5	1100.0	230.0	200.0	132.0	140.0	3.4	35.0	28.0	10.0	140

TABLE 5.1

RESULTS OF ARSENIC PRE-TREATMENT EXPERIMENT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Parameter	*Raw Water Mixture 2003-01-10*	*Pre-Treated Water Test 1 (30 mg H2O2)*		*Pre-Treated Water Test 2 (40 mg H2O2)*		*Pre-Treated Water Test 3 (50 mg H2O2)*	
		Concentration (mg/L)	*Removal (%)*	*Concentration (mg/L)*	*Removal (%)*	*Concentration (mg/L)*	*Removal (%)*
pH (Std)	8.1	7.1	-	7.2	-	7.2	-
Phenol (4AAP)	111	106	4.50	93	16.22	91	18.02
Thiocyanate	210	166	20.95	160	23.81	172	18.10
Total Cyanide	1.95	0.26	86.67	0.2	89.74	0.18	90.77
Total Organic Carbon	412	390	5.34	388	5.83	392	4.85
Total Suspended Solids	23	4	82.61	6	73.91	7	-
Arsenic	7.1	2.2	69.01	1.1	84.51	0.73	89.72

TABLE 5.2

PRE-TREATED GROUNDWATER COMPOSITES (BATCHES) USED IN NITRIFICATION STUDY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

	Parameter (mg/L)													
Date	*pH*	*NH_3-N*	*TKN*	*NO_3-N*	*COD*	*TOC*	*DOC*	*Phenols*	*Thiocyanate*	*Total Cyanide*	*TSS*	*VSS*	*Arsenic*	*Sulfate*
2/28/2003	7.6	602.0	720.0	2.0	1300.0	412.0	406.0	120.0	66.0	2.6	<1	<1	2.0	230
3/27/2003	7.8	518.0	550.0	1.0	1300.0	350.0	346.0	122.0	160.0	3.3	9.5	1.0	0.7	230
4/8/2003	7.6	540.0	760.0	1.0	1400.0	364.0	348.0	134.0	160.0	3.6	2.4	2.0	1.2	250
4/14/2003	7.5	580.0	790.0	1.0	1300.0	367.0	338.0	104.0	150.0	2.9	6.0	2.0	1.5	260
4/26/2003	7.6	610.0	770.0	1.0	1300.0	372.0	346.0	112.0	160.0	2.9	12.0	6.0	1.1	240
5/14/2003	7.4	610.0	770.0	1.0	1300.0	372.0	349.0	112.0	160.0	2.9	12.0	6.0	1.1	250
5/24/2003	7.8	560.0	670.0	1.0	1350.0	392.0	342.0	102.0	146.0	2.6	12.0	6.0	0.9	300
5/30/2003	7.8	590.0	660.0	1.0	1380.0	389.0	348.0	92.0	142.0	2.2	12.0	9.0	1.9	260
6/12/2003	7.6	490.0	510.0	2.2	1180.0	240.0	160.0	97.0	180.0	2.8	22.0	14.0	1.3	260
6/23/2003	7.8	500.0	650.0	3.5	1200.0	300.0	240.0	140.0	76.0	2.9	180.0	98.0	1.5	270
6/30/2003	7.6	540.0	550.0	0.5	1400.0	360.0	310.0	210.0	160.0	3.1	20.0	16.0	2.2	260

TABLE 5.3

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1
ACCLIMATIZATION USING DOFASCO SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Operational Parameters					Analytical Data (mg/L)			NH_3-N nitrif	NH_3-nitr/VSS	Comments
	pH (St Un)	DO (mgO_2/L)	DO(15 min)	Feed (ml)	NH_3-N load (mg/L)	NH_3-N	NO_3-N	VSS	(mg/L)		
Jan-13	8.1	6.5	5.8	500	16.8	0.9	0.9	4800			
Jan-14	8.2	6.6	5.7	0	0	2.8	1.2	4800			
Jan-15	8.7	6.4	5.8	500	16.8	19	1.6	4800			unstable pH, soda ash
Jan-16	7.9	6.5	5.1	0	0	17	3.3	4800			unstable pH, sugar 3 g
Jan-17	8.6	6.2	4.8	0	0	9.2		4800	7.8	0.0016	soda ash added, sugar 3g
Jan-18	7.4	6.4	4.2	0	0	22	7.2	4800			soda ash added, sugar 3g
Jan-19	6.8	6.1	3.8	0	0	18		4800	4	0.0008	buffer added, sugar 2 g
Jan-20	6.9	6.2	3.9	0	0	16	8.6	4800	2	0.0004	buffer added, sugar 1 g
Jan-21	8.4	6.3	3.4	0	0	3.2		4800	12.8	0.0027	
Jan-22	8.2	5.8	3.2	0	0	3	7.2	4800	0.2	0.0000	buffer added,
Jan-23	7.6	5.9	3.1	0	0	1.2		5200	1.8	0.0003	
Jan-24	7.4	6	3.5	0	0	0.3	9.2	5200	0.9	0.0002	
Jan-25	7.7	6.2	3.3	0	0	0.2		5200	0.1	0.0000	
Jan-26	7.3	4.8	2.3	600	20.2	0.2	8.6	5200			
Jan-27	7.8	5.5	2.41	0	0	4.2		4900	16	0.0033	soda ash,
Jan-28	7.2	4.6	2.3	650	21.9	3.3		4900	0.9	0.0002	
Jan-29	7.5	5	2.2	0	0	1.2	8.8	4900	24	0.0049	soda ash,
Jan-30	8.0	5.2	2.75	0	0	1.1		6900			
Jan-31	7.6	5 15	2.6	650	21.9	0.8	9.1	6900	0.3		buffer 2 ml
Feb-01	8.1	4.7	2.2	0	0	12		6900	10.7	0.0016	
Feb-02	8.1	4.2	2.1	0	0	5.5		6900	6.5	0.0009	
Feb-03	7.3	4.4	1.9	0	0	3.6		6900	1.9	0.0003	
Feb-04	7.6	5.6	3.3	0	0	5.4		6900			
Feb-05	7.8	5.4	2.7	0	0	5.7		6900			

TABLE 5.4

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
ACCLIMATIZATION USING DOFASCO SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Operational Parameters					Analytical Data (mg/L)			NH_3-N nitrif	NH3-nitr/VSS	Comments
	pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml)	NH3-N load (mg/L)	NH3-N	NO3-N	VSS	(mg/L)		
Jan-18	8.6	6.2	4.8	500	16.8	3.2	_	4600			soda ash added, sugar 3g
Jan-19	7.4	6.4	4.2			2.2	2.3	4600			buffer added, sugar 2 g
Jan-20	7.8	6.1	3.8			1.8		4600	0.4	0.0001	buffer added, sugar 2 g
Jan-21	7.9	6.2	3.9	500	16.8	30	4.6	4600			buffer added, sugar 2 g
Jan-22	8.4	6.3	3.4			13		4600	17	0.0037	
Jan-23	8.2	5.8	3.2			7.2	7.3	4600	5.8	0.0013	buffer added, sugar 1 g
Jan-24	7.6	5.9	3.1			1.2		5100	6	0.0012	
Jan-25	7.4	6	3.5			0.3	7.2	5100	0.9	0.0002	soda ash, buffer 2ml
Jan-26	7.7	6.2	3.3			0.2		5100	0.1	0.0000	
Jan-27	7.3	4.8	2.3	600	20.2	5.8		4800			
Jan-28	6.8	5.6	2.6			1.4	8.6	4800	24.6	0.0051	soda ash,
Jan-29	7.2	5	2.2	650	21.9	3.3		4800			
Jan-30	7.5	4.98	2.1			6.5		4800	18.7	0.0039	soda ash, buffer 2 ml
Jan-31	7.9	5.2	2.1			3.1		5250	3.4	0.0006	
Feb-01	7.8	4.5	1.9	650	21.9	0.8	8.8	5250	2.3	0.0004	
Feb-02	8.1	3.2	1.8			22		5250	0.7	0.0001	soda ash, buffer 2 ml
Feb-03	7.6	3	1.7			18		5250	4	0.0008	
Feb-04	7.8	5.6	2.2			15			3		
Feb-05	7.6	5.3	3.1			7					

TABLE 5.5

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR3
ACCLIMATIZATION USING DOFASCO SLUDGE
WAUKEGAN MANUFACTURING GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Operational Parameters*				*Analytical Data (mg/L)*		
	pH (St Un)	*DO (mgO_2/L)*	*Feed (ml)*	*NH_3-N load (mg/L)*	*NH_3-N*	*NO_3-N*	*VSS*
Jan-13	8.1	6.6	10	0.40	0.9	0.58	4800
Jan-14	8.2	6.6	20	0.80	0.7		
Jan-15	8.2	6.4	20	0.80	0.6		
Jan-16	7.9	6.5	30	1.20	0.3	1.3	
Jan-17	7.6	6.7	50	2.00	0.1		
Jan-18	7.4	6.4	60	2.40	0.22		
Jan-19	7.6	6.1	75	3.00	0.25	2.9	
Jan-20	7.6	6.2	90	3.60	0.3		
Jan-21	7.6	6.3	90	3.60	0.2		
Jan-22	7.8	6.6	120	4.80	0.8	3.6	4900
Jan-23	7.6	6.3	120	4.80	0.2		
Jan-24	7.6	6	120	4.80	0.12		
Jan-25	7.6	6.2	150	6.00	0.9	4.9	
Jan-26	7.3	6.2	150	6.00	0.21		
Jan-27	7.8	6.1	170	6.80	0.8		
Jan-28	7.2	5.6	180	7.20	1.2		
Jan-29	7.5	5.4	200	8.00	1.4	6.4	4900
Jan-30	7.8	5.8	200	8.00	0.8		
Jan-31	7.6	5.1	200	8.00	0.7		
Feb-01	7.8	5.3	200	8.00	0.5	8.6	
Feb-02	7.4	5.2	200	8.00	0.3		
Feb-03	7.3	5.4	200	8.00	0.09		
Feb-04	7.6	5.6	200	8.00	0.09	12	4950
Feb-05	7.8	5.4	200	8.00	0.08		

TABLE 5.6

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					Temperature (oC)	TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS	NH_3-N nitrif NH_3-nitr/VSS (mg/L)	Comments
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml) Water	Feed (ml) Groundwater			COD	NH3-N	NO3-N	TSS VSS			
Feb-09	9:00	6 7.3	6.4	2.3			25			3.2					no feed
	18:00	6 7.6	5.8	2.4			27			3.1			14000/21200		no feed
Feb-10	9:00	6 7.8	5.6	2.3			27			2.8			R =0.66		
	18:00	6 7.4	5.8	2.2			27			2.6					
Feb-11	9:30	5 7.8	5.2	2.7	2700	300	27	26.2		2.3				26.5	
	18:00	6 7.3	5.8	2.5			27			2.2					
Feb-12	9:30	5 7.9	5.4	1.9	2500	400	26	34.9		0.2				35.4	
	18:00	6 7.3	6.2	3.4			26			0.3					
Feb-13	9:30	5 7.4	5.2	2.1	2500	500	26	43.5		0.3				45.6	0.5 g Na2CO3
	18:00	6 7.2	5.8	2.5			26			0.6					
Feb-14	9:30	6 7.8	5.6	2.2	2100	600	26	52.0	130	0.3	96		15000/21800	51.9	0.8 g Na2CO3
	17:30	6 8	5.8	2.4			26			0.35			R = 0.688		
Feb-15	9:00	5 7.6	5.4	2.3	2300	700	26	60.7	220	0.4	98			60.7	1.0 g Na2CO3
	18:00	6 7.5	5.5	2.2			26			0.2					
Feb-16	9:00	6 7.6	5.6	2.1	2200	800	28	69.4	240	0.15	103			69.3	poor settling, flocculants added
	17:30	6 7.2	5.9	2.5			28			0.2					
Feb-17	9:00	6 7.3	6.2	2.1	2100	900	28	78.0	280	0.16	110	103 76		78.3	1.0 g Na2CO3, flocculant
	17:30	6 7.2	5.8	2.3			28			0.23					
Feb-18	9:30	6 7.6	5.6	2.2	2300	1000	27	86.7	340	0.5	120	120 88		86.7	2.0 g Na2CO3
	18:00	6 6.5	5.5	2.4			27			2.2					
Feb-19	9:00	5 6.7	5.4	2.1	3300	0	26	0	320	10.2	110	170 102	19000/26500		2.0 g Na2CO3, no feed
	18:00	6 6.5	5.8	2.3			27			8.2			R = 0.716		5.0 g Na2CO3, no feed
Feb-20	9:00	6 7.8	5.6	2.2	3300	0	27	0	135	7.8	102	180 103			5.0 g Na2CO3, no feed
	18:00	6 7.6	5.6	2.2			27			7.1					

TABLE 5.7

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date		Operational Parameters							Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	Comments
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml/day)		Temperature	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	
					Water	Groundwater	(oC)									
Feb-09	9:00	7.3	6.4	2.3			26	0.0		3.5						
		7.6	5.8	2.4			26			3.1						no feed
Feb-10	9:00	7.8	5.6	2.3			26	0.0		2.7				14000/21200	17.3	
	18:00	7.4	5.8	2.2			26			1.6				R = 0.66		
Feb-11	9:00	7.8	5.2	2.7	2700	300	26	16.2		0.1					21.4	1.0 g Na2CO3
	18:00	7.3	5.8	2.6			26			0.15						
Feb-12	9:00	7.9	5.4	1.9	2600	400	26	21.4		0.2					26.6	2 ml buffer
	18:00	7.3	6.2	3.4			26			0.3						
Feb-13	9:00	7.4	5.2	2.1	2500	500	26	26.7		0.4					32.2	0.6 g Na2CO3
	18:00	7.2	5.8	2.6			26			0.2						
Feb-14	9:00	7.8	5.6	2.2	2400	600	26	32.0		0.15				15800/22800	37.3	0.9 g Na2CO3
	17:30	8	5.8	2.4			26			0.2				R = 0.692		
Feb-15	9:00	7.6	5.4	2.3	2300	700	26	37.3	180	0.35	110				42.7	1.0 g Na2CO3, flocculant
	18:00	7.5	5.5	2.2			26			0.3						
Feb-16	9:00	7.6	5.6	2.1	2200	800	26	42.7	100	0.4	110				48.2	1.0 g Na2CO3, flocculant
	18:00	7.2	5.9	2.5			28			0.25						
Feb-17	9:00	7.3	6.2	2.1	2100	900	28	48.0	150	0.2	112				53.3	2.0 g Na2CO3
	17:30	7.2	5.8	2.5			28			0.15						
Feb-18	9:00	7.6	5.6	2.2	2000	1000	27	53.3	260	0.5	115				-0.3	2.0 g Na2CO3
	18:00	6.4	5.5	2.4			27			0.8						
Feb-19	9:00	6.5	5.4	2.1	3000	0	26	0	220	8.9	110			15200/21600		5.0 g Na2CO3
	18:00	6.6	5.8	2.3			28			7.3				R = 0.703		
Feb-20	9.00	7.8	5.6	2.2	3000	0	28	0	240	7.6	96					5.0 g Na2CO3, no feed
	18:00	7.6	5.6	2.2			28			9.2						

TABLE 5.8

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR3
ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Operational Parameters*					*Analyses*	*Comments*
	pH (St Un)	*DO (mgO2/L)*	*DO(15 min)*	*Feed (ml)*		NH_3-N	
				Water	*Groundwater*		
Feb-09	7.3	5.6	2.3				
Feb-10	7.6	5.6	2.3				
Feb-11	7.5	5.2	2.7	300	100	0.2	
Feb-12	7.6	5.3	2.3	250	100	0.3	3.0 g Na2CO3
Feb-13	7.4	5.2	2.1	250	100	0.1	
Feb-14	7.8	5.6	2.2	350	100	0.1	2.0 g Na2CO3
Feb-15	7.6	5.4	2.3	300	200	0.1	
Feb-16	7.6	5.6	2.1	300	200	0.2	
Feb-17	7.3	6.2	2.1	250	200	0.4	
Feb-18	7.6	5.6	2.2	250	200	0.3	
Feb-19	6.9	5.4	2.1	300	200	0.2	1.5 g Na2CO3
Feb-20	7.8	5.6	1.9	250	250	0.25	
Feb-21	7.4	6.2	2.2	250	250	0.35	2.0 g Na2CO3
Feb-22	7.6	5.8	2.3	300	250	0.6	2.0 g Na2CO3
Feb-23	7.8	5.4	1.9	250	250	0.2	solids recycled R # 1 & 2
Feb-24	7.2	5.6	2.2	350	300	0.25	1.5 g Na2CO3
Feb-25	7.9	5.4	2.2	300	300	0.3	solids recycled R # 1 & 2
Feb-26	7.6	5.2	1.9	400	300	0.35	solids recycled R # 1 & 2
Feb-27	7.2	5.6	2.1	400	300	0.3	1.5 g Na2CO3
Feb-28	7.9	5.4	2.2	350	300	0.2	solids recycled R # 1 & 2

TABLE 5.9

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1, RECOVERY FROM UPSET
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURING GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS	Comments
	pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml) Water	Feed (ml) Groundwater		COD	NH3-N	NO3-N	VSS		
20-Feb	6.5	5.6	1.9	3000	0	0	135	7.8	102	103	19000	2.0 g Na2CO3, no feed
21-Feb	8.1	6.2	2.2	3000	0	0	140	13.6	93	60		5.0 g Na2CO3, no feed
22-Feb	8.2	6.3	2.3	3000	0	0	180	16.2	78	98		5.0 g Na2CO3, no feed
23-Feb	7.8	5.9	1.9	3000	0	0	160	14.3	79	88		3.0 g Na2CO3, no feed, 2 ml Buffer
24-Feb	7.6	5.6	2.1	3000	0	0	155	6.8	80	73	16000	2.0 g Na2CO3, no feed, 2 ml Buffer
25-Feb	7.9	5.4	2.2	3000	0	0	118	11.4	72	70		1.0 g Na2CO3, no feed
26-Feb	8.1	5.9	1.9	3000	0	0	130	8.6	56	36		1.0 g Na2CO3, no feed
27-Feb	7.8	5.6	2.1	3000	0	0	110	7.6	42	54		4.0 g Na2CO3, no feed
28-Feb	7.9	5.4	2.2	3000	0	0	116	8.8	36	57		1.0 g Na2CO3, no feed
1-Mar	8.2	6.3	2.2	3000	0	0	122	7.8	32	46		3.0 g Na2CO3, no feed
2-Mar	7.8	5.9	2.3	3000	0	0	130	7.2	29	59		1.0 g Na2CO3, no feed
3-Mar	8.2	6.3	1.9	3000	0	0	108	7.2	27	48	9300	1.0 ml buffer, 300 ml AS R#3
4-Mar	7.8	5.9		2800	200	10.5	120	0.5	34	42		1.0 ml buffer, 500 ml AS R#3
5-Mar	7.6	5.6	2.2	2700	300	15.8	86	0.8	36	47		1.0 ml buffer, 300 ml AS R#3
6-Mar	7.9	6.3	2.3	2700	300	15.8	84	0.9	39	38		1.0 ml buffer, 300 ml AS R#3
7-Mar	8.1	5.9	2.2	2700	300	15.8	71	0.15	41	18		
8-Mar	7.8	5.9	2.3	2700	300	15.8	74	0.22	45	32	7700	
9-Mar	7.6	5.6	1.9	2700	300	15.8	69	0.6	48	41		
10-Mar	7.9	5.4	2.1	2700	300	15.8	59	0.3	52	16		additional heater & aerator
11-Mar	8.1	5.9	2.2	2700	300	15.8	60	0.16	56	26		
12-Mar	7.8	5.6	1.9	2700	300	15.8	62	0.4	58	32		

TABLE 5.10

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2, RECOVERY FROM UPSET
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS	Comments
	pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml)			COD	NH3-N	NO3-N	VSS		
				Water	Groundwater							
20-Feb	7.5	5.6	2.1	3000	0	0	240	7.3	96		18000	2.0 g Na2CO3, no feed
21-Feb	7.6	6.2	2.2	3000	0	0	190	19.1	86	60		1.0 ml buffer, 200 ml AS R # 3
22-Feb	7.8	6.3	2.3	3000	0	0	160	21	75	190		5.0 g Na2CO3, no feed
23-Feb	7.8	6.1	1.9	3000	0	0	170	17	73	180		1.0 ml buffer, 200 ml AS R # 3
24-Feb	7.6	5.6	2.1	3000	0	0	160	17.1	72	64		1.0 ml buffer, 200 ml AS R # 3
25-Feb	7.9	5.4	2.2	3000	0	0	110	10.5	68	59	15000	1.0 ml buffer, 200 ml AS R # 3
26-Feb	7.8	5.9	1.9	3000	0	0	140	12.6	53	18	-	1.0 ml buffer
27-Feb	7.8	5.6	3.1	3000	0	0	130	10.2	35	9	-	1.0 ml buffer, 200 ml AS R # 3
28-Feb	7.9	5.7	2.2	3000	0	0	150	9.2	32	12	-	1.0 ml buffer, 300 ml AS R # 3
1-Mar	7.5	6.3	2.2	3000	0	0	120	8.6	29	24	16200	
2-Mar	7.8	5.4	2.3	3000	0	0	110	5.2	28	22		1.0 ml buffer
3-Mar	7.4	6.3		3000	0	0	98	5.0	26	25		
4-Mar	7.8	5.9	2.1	2800	200	9.6	120	0.16	36	38		
5-Mar	7.6	6.2	2.2	2700	300	14.4	98	0.3	38	54	13300	1.0 ml buffer
6-Mar	7.9	6.3	2.2	2700	300	14.4	92	0.22	40	60		
7-Mar	8.1	6.2	2.2	2700	300	14.4	78	0.13	45	26		1.0 ml buffer
8-Mar	7.8	5.9	2.3	2700	300	14.4	84	0.52	49	53		
9-Mar	7.6	5.6	1.9	2700	300	14.4	76	0.35	54	32	12700	1.0 ml buffer
10-Mar	7.9	5.4	2.1	2700	300	14.4	82	0.12	58	28		additional heater & aerator
11-Mar	8.1	5.9	1.8	2700	300	14.4	34	0.2	63	36		
12-Mar	7.6	5.6	2.3	2700	300	14.4	59	0.11	68	38		

TABLE 5.11

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1 (HRT =7.5 days)
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters						TKN load (mg/L)#	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif	NH3-nitr/VSS (mg/L)	Comments
		pH (St Un)	DO (mgC2/L)	DO (15 min)	Feed (ml) Water	Feed (ml) Groundwater	Temperature (oC)		COD	NH3-N (*)	NO3-N	TSS	VSS				
Mar-03	9:30	7.7	5.7	2.6	3000	0	26	0	108	7.2	27	56	48	9300/13800			1.0 ml buffer, 500 ml As R # 3
	17:30	7.3	6.5	1.9			25			3.8				R = 0.674			
Mar-04	8:30	7.4	5.3	2.7	2800	200	25	10.5	120	0.5	34	48	42			0.0024	New Feed, 1.0 ml buffer
	17:30	8.1	6.2	2.6			26			0.6							
Mar-05	8:30	7.8	5.4	2.2	2700	300	26	15.8	86	0.8	36	53	47		22.5	0.0017	1.0 ml buffer
	17:00	7.8	5.5	2.4			26			0.7							
Mar-06	9:00	7.9	5.2	2.2	2700	300	27	15.8	84	0.9	39	49	38		15.5	0.0017	1.0 ml buffer
	17:00	7.6	5.7	2.6			27			0.4							
Mar-07	9:30	7.8	5.4	1.8	2700	300	26	15.8	71	0.15	41	23	18		15.7	0.0018	1.0 ml buffer
	17:00	7.7	6.2	2.6			26			0.22							
Mar-08	9:30	7.8	5.4	2.2	2700	300	26	15.8	74	0.18	45	39	32	7700/12000	16.6	0.0020	1.0 ml buffer
	17:30	8.1	5.5	2.4			26			0.54				R =0. 641			1.0 ml H3PO4
Mar-09	8:30	8	5.2	2.2	2700	300	26	15.8	69	0.6	48	46	41		15.8	0.0020	
	17:30	8.1	5.7	2.6			26			0.8							
Mar-10	9:00	7.8	5.4	1.8	2700	300	27	15.8	59	0.3	52	19	16		15.4	0.0021	additional heater & aerator
	18:00	7.9	5.9	2.5			27			0.22							pH controllers calibrated
Mar-11	9:00	7.7	5.7	2.6	2700	300	28	15.8	60	0.16	56	31	26		16.1	0.0021	
	17:30	7.8	6.5	1.9			28			0.2							1.0 ml buffer
Mar-12	9:00	8.1	5.8	2.4	2700	300	27	15.8	62	0.4	58	44	32		15.9	0.0027	
	17:00	7.8	5.7	2.5			27			0.22							
Mar-13	9:00	7.6	5.4	5.4	1600	400	27	21.1	58	0.25	64	23	20		20.8	0.0028	
	16:30	7.7	6.2	6.2			27			0.18							
Mar-14	8:30	7.8	5.4	5.4	1600	400	27	21.1	45	0.28	68	17	10		21.2	0.0027	
	17:00	7.7	5.5	5.5			27			0.32							
Mar-15	9:00	7.6	5.2	5.2	1600	400	27	21.1	49	0.38	72	35	27		21.0	0.0031	
	17:00	7.6	5.7	5.7			27			0.24							
Mar-16	9:00	7.5	5.8	5.8	1550	450	26	23.7	52	0.2	74	42	36		23.6	0.0031	
	16:30	7.6	5.7	5.7			27			0.28							
Mar-17	9:00	7.7	5.7	5.7	1550	450	27	23.7	48	0.16	81	33	28	7600/11900	23.9	0.0035	
	17:30	7.6	6.6	6.6			28			0.44				R = 0.638			
Mar-18	8:30	7.5	6.5	6.5	1500	500	28	26.3	53	0.12	88	25	18		26.4	0.0042	
	18:00	7.6	6.4	6.4			28			0.77							
	23:00	7.6	6.4	6.4			28			0.8					31.6		
Mar-19	8:30	7.5	6.3	6.3	1400	600	28	31.6	70	0.09	100	55	36			0.0049	
	17:00	7.6	6.6	6.6			27			0.67							
	23:00	7.7	6.5	6.5			27			0.58					37.5		
Mar-20	9:00	7.6	6.4	6.4	1300	700	28	36.9	43	0.2	110	20	15			0.0056	
	17:00	7.6	6.8	6.8			27			0.65							
	23:00	7.6	6.5	6.5			28			0.8					42.6		
Mar-21	9:00	7.5	6.2	6.2	1200	800	28	42.1	49	0.52	120	30	22				500 ml ML from R#3
	17:00	7.6	6.4	6.4			28			0.34							
	23:00	7.6	6.4	6.4			29			0.36					47.5		
Mar-22	9:30	7.5	6.5	6.5	1100	900	28	47.4		0.26							
	16:30	7.5	6.4	6.4			28			0.48							
	23:00	7.7	6.3	6.3			28			0.46					50.1		
Mar-23	9:30	7.5	6.5	6.5	1050	950	28	50.0		0.17						0.0078	
	16:00	7.5	6.6	6.6			28			0.37							
	23:00	7.6	6.3	6.3			28			0.42					53.0		

TABLE 5.11

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1 (HRT =7.5 days)
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Time*	*Operational Parameters*						*TKN load (mg/L)#*	*Effluent Analytical Data (mg/L)*					*MLVSS/MLTSS Ratio*	*NH3-N nitrif*	*NH3-nitr/VSS (mg/L)*	*Comments*
		pH (St Un)	*DO (mg/L) 1.5 min*		*Feed (ml)*		*Temperature*		*COD*	*NH3-N (*)*	*NO3-N*	*TSS*	*VSS*				
					Water	*Groundwater*	*(oC)*										
Mar-24	9:00	7.6	6.7	6 7	1000	1000	28	52.7	73	0.18	162	6	5	6800/10700		0.0085	
	17:00	7.6	5.8	5 8			29			0.72				R = 0. 636			
	23:00	7.5	5.9	5 9			29			0.52					58.1		
Mar-25	9:00	7.5	5.8	5 8	900	1100	29	57.9		0.15						0.0094	
	16:30	7.4	6	6			28			0.68							
	23:00	7.5	5.9	5 9			29			0.3					63.8		
Mar-26	9:00	7.6	6.2	6 2	800	1200	29	63.2		0.14						0.0105	
	17:00	7.6	5.8	5 8			29			0.73							
	23:00	7.6	6.1	6 1			29			0.86					71.6		
Mar-27	9:00	7.5	5.9	5 9	650	1350	29	71.1	67	0.05	180	12	9				
	16:30	7.5	5.8	5 8			29			0.26							
	23:00	7.4	6.2	6 2			29			0.43					79.7		
Mar-28	9:00	7.5	5.8	5 8	500	1500	29	79.0		0.16							
	16:30	7.5	6.3	6 3			29			0.53							
	23:00	7.5	6.4	6 4			28			0.68					84.4		
Mar-29	9:00	7.6	5.9	5 9	400	1600	28	84.3		0.13						0.0138	
	16:30	7.5	7.2	7 2			29			0.23							
	23:00	7.5	6.4	6 4			29			0.46					89.9		
Mar-30	9:00	7.4	6.3	6 3	300	1700	29	89.5		0.19						0.0145	
	16:30	7.5	5.9	5 9			30			0.38							
	23:00	7.6	5.8	5 8			29			0.42					94.8		
Mar-31	9:30	7.5	6	6	200	1800	29	94.8	58	0.09	190	6	5	6540/10100		0.0153	
	17:00	7.3	7.4	7 4			29			1.9				R =0.648			
	23:00	7.4	6.9	6 9			28			0.82					100.4		
Apr-01	9:00	7.5	7.2	7 2	100	1900	28	100.1		0.2							
	16:00	7.5	7	7			28			2.2							
	23:00	7.5	7.2	7 2			28			0.88							

TABLE 5.12

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2 (HRT =7.5 days)
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters						TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)	Comments
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Feed (ml) Water	Feed (ml) Groundwater	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS				
3/13/2003	9:00	7 6	6.7	2.2	1600	400	27	14.4	57	0.08	72	35	24		19.1		1.0 ml buffer
	18:00	7 5	6.5	2.2			27			0.18							
3/14/2003	9:00	7 6	6.3	2.4	1550	450	27	19.2	62	0.36	79	46	39		24.2		
	18:00	7 5	5.8	2.3			27			0.16							
3/15/2003	9:00	7 6	5.9	2.2	1500	500	27	24.0	72	0.38	83	48	39		24.2		
	18:00	7 6	6.6	2.8			27			0.2							
3/16/2003	9:00	7 8	6.2	2.2	1500	500	27	24.0	88	0.46	87	38	32		24.3		
	18:00	7 6	6.4	2.6			27			0.2							
3/17/2003	9:00	7 7	6	2.4	1500	500	27	24.0	90	0.38	92	35	27	10700/16000	33.7	0.00315	100 ml ML wasted
	17:30	7 7	6.3	_			29			0.27				R = 0.668			
3/18/2003	9:00	7 6	5.8	1.9	1300	700	29	33.6	87	0.17	110	33	22		38.2	0.00357	
	18:00	7 6	6.4	_			28			0.39							
	23:00	7 7	6.6	_			28			0.59							
3/19/2003	9:00	7 6	7.2	3.2	1200	800	29	38.4	82	0.15	130	31	22		47.7	0.00446	100 ml ML wasted
	17:00	7 6	6.6	_			28			0.41							
	23:00	7 5	6.5	_			28			0.6							
3/20/2003	9:00	7 6	6.4	2.8	1000	1000	28	48.0	62	0.17	137	24	16		52.3	0.00489	100 ml ML wasted
	17:00	7 6	6.4	_			28			0.64							
	23:00	7 6	6.3	_			28			0.7							
3/21/2003	9:00	7 7	5.9	2.2	900	1100	29	52.8	73	0.16	160	30	28		62.1		100 ml ML wasted
	17:00	7 6	5.8	_			29			0.51							
	23:00	7 5	6.2	_			29			0.52							
3/22/2003	9:00	7 5	6.4	2.3	700	1300	29	62.4		0.26					66.9		100 ml ML wasted
	16:30	7 5	6.4	_			29			0.58							
	23:00	7.6	6.7	_			28			0.53							
3/23/2003	9:00	7.5	6.3	2.4	600	1400	29	67.2		0.17					76.3	0.00830	100 ml ML wasted
	16:00	7.6	6.2	_			28			0.43							
	23:00	7.6	6.5	_			28			0.48							
3/24/2003	9:00	7.6	6.3	2.6	400	1600	28	76.6	68	0.18	210	11	7	9200/14700	81.2	0.00882	
	17:00	7.5	6.6				29			0.63				R = 0.626			
	23:00	7.6	6.7				29			0.2							
3/25/2003	9:00	7.6	6.8	2.8	300	1700	29	81.6		0.16					86.6	0.00941	
	16:30	7.5	7.3				28			0.19							
	23:00	7.7	6.8				29			0.3							
3/26/2003	9:00	7.6	6.7	2.7	200	1800	29	86.6		0.22					85.3	0.00927	
	17 00	7.4	5.8				28			1.5							
	23 00	7.5	6.2				28			5.5							Feed disconnected
3/27/2003	9:00	7.5	6.8	2.6	200	1800	29	86.6	70	0.17	230	9	8		90.7		
	16 30	7.6	6.6				29			0.76							
	23 00	7.5	6.8				29			0.87							
3/28/2003	9:00	7.5	7 4	2.9	100	1900	28	91.3		0.18					90.6		
	16 30	7.6	7 3				29			0.92							
	23:00	7.6	7 1				29			0.86							
3/29/2003	9:00	7.5	6 9	2.8	100	1900	29	91.3		0.16					95.5	0.01137	
	16:30	7.5	6 8				28			0.68							
	23:00	7.6	6 4				29			0.72							

TABLE 5.12

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2 (HRT =7.5 days)
INITIAL ACCLIMATIZATION USING CLAIRTON SLUDGE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters						TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLT SS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)	Comments
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Feed (ml) Water	Feed (ml) Groundwater	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS				
3/30/2003	9:00	7.4	6.9	2.7	0	2000	30	96.0		0.18					95.5	0.01137	
	16:30	7.5	6.7				30			0.68							
	23:00	7.5	7.2				29			0.66							
3/31/2003	9:30	7.6	6.9	2.8	0	2000	29	96.0	76	0.16	270	12	10	8400/13500	94.7	0.01127	
	17:00	7.4	5.6				28			1.5				R = 0. 622			
	23:00	7.5	5.8				29			0.8							
4/1/2003	9:00	7.5	5.8	2.5	0	2000	29	96.0		0.2					-0.2	-0.00003	
	16:00	7.5	6..3				30			0.43							
	23:00	7.6	5.9				29			0.56							

TABLE 5.13

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR THE REACTOR SBR-1
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Groundwater (ML)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
4/2/2003	9:00	7.4	7.6	3.2	2000	29	105.3		0.2						
	17:00	7.3	7.4			29			3.1						
	23:00	7.4	7.2			29			4.1						
4/3/2003	9:00	7.4	7.3	3.4	2000	28	84.3	58	0.23	280	10	8	6730/10400		
	17:00	7.5	7.5			28			1.5				R = 0.647		
	23:00	7.5	7.4			28			2.2						
4/4/2003	9:00	7.4	7.2	3.3	2000	29	105.3		0.24					84.3	0.01289
	16:30	7.4	7.6			28			1.6						
	23:00	7.5	6.9			29			0.96						
4/5/2003	9:00	7.4	7.4	3.6	2000	28	105.3		0.16					105.4	0.01611
	17:00	7.5	7.2			29			1.1						
	23:00	7.5	7.6			28			0.88						
4/6/2003	9:00	7.4		3.1	2000	29	105.3		0.23					105.2	
	17:00	7.4	7.2			28			0.86						
	23:00	7.5	7.3			28			0.82						
4/7/2003	9:00	7.5	7.8	3.5	2000	28	105.3		0.17				6900/10500	105.4	0.01527
	16:30	7.4	6.9			28			0.18				R = 0.657		
	23:00	7.5	7.4			28			0.68						
4/8/2003	8:30	7.4	7.2	3.4	2000	28	105.3		0.14					105.3	0.01527
	17:00	7.4	7.5			29			1.1						
	23:00	7.6	7.4			28			1.6						
4/9/2003	9:00	7.5	7.2	3.2	2000	29	105.3	62	0.21	350	18	15		105.2	0.01442
	17:30	7.4	7.6			28			0.3						
	23:00	7.5	6.9			28			0.82						
4/10/2003	9:00	7.6	7.3	3.1	2000	28	105.3		0.18				7300/11700	105.4	0.01443
	17:00	7.4	7.2			28			3.1				R = 0.624		
	23:00	7.5	7.6			29			1.6						
4/11/2003	9:00	7.5	7.4	2.9	2000	28	105.3		0.27					105.2	0.01442
	16:30	7.4	7.2			29			1.3						
	23:00	7.4	7.3			28			0.89						
4/12/2003	8:30	7.5	7.8	2.8	2000	28	105.3		0.05					105.6	0.01100
	17:00	7.5	7.2			28			1.2						
	23:00	7.4	7.6			28			0.86						
4/13/2003	9:00	7.5	7.4	2.9	2000	29	105.3		0.14				9600/13800	105.2	0.01096
	17:30	7.4	7.2			28			0.96				R = 0.695		
	23:00	7.4	7.3			29			0.65						
4/14/2003	9:00	7.6	7.8	2.6	2000	28	105.3		0.12					105.4	0.01097
	17:00	7.3	6.9			28			0.28						
	23:00	7.4	7.4			28			0.32						

TABLE 5.13

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR THE REACTOR SBR-1
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Groundwater (ML)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
4/15/2003	9:00	7.4	7.2	2.4	2000	28	105.3		0.14					105.3	
	17:30	7.4	7.4			28			0.16						
	23:00	7.5	7.3			29			0.63						
4/16/2003	9:00	7.4	7.2	2.2	2000	28	105.3		0.12					105.4	0.01301
	17:00	7.4	7.6			29			0.81						
	23:00	7.5	7.4			28			0.76						
4/17/2003	9:30	7.5	7.2	2.6	2000	28	105.3		0.13				8100/11600	105.3	0.01300
	16:30	7.4	7.3			28			0.92				R = 0.698		
	23:00	7.4	7.8			28			0.64						
4/18/2003	9:30	7.5	7.2	2.5	2000	29	105.3		0.15					105.3	0.01300
	17:00	7.5	6.7			28			0.15						
	23:00	7.4	6.2			28			0.26						
4/19/2003	9:00	7.3	6.4	1.9	2000	29	105.3		0.08					105.4	
	16:00	7.4	6.2			28			0.24						
	23:00	7.4	5.9			29			0.33						
4/20/2003	8:30	7.5	6.7	2.8	2000	28	105.3		0.07					105.3	0.01225
	16:30	7.3	6.2			28			0.22						
	23:00	7.4	6.4			28			0.31						
4/21/2003	8:00	7.4	6.7	2.3	2000	29	110.7	40	0.1	380	6	3	8600/12300	105.3	0.01224
	16:00	7.4	6.2			29			0.17				R = 0.699		
	23:00	7.5	6.4			28			0.32						
4/22/2003	9:00	7.5	6.2	1.8	2000	29	110.7		0.15					110.6	0.01286
	16:00	7.4	5.9			28			0.22						
	23:00	7.3	6.7			28			0.28						
4/23/2003	8:30	7.4	6.2	2.2	2000	28	110.7		0.14					110.7	0.01333
	16:30	7.4	6.4			28			0.18						
	23:00	7.5	6.2			29			0.23						

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR THE REACTOR SBR-1
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Groundwater (ML)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
4/24/2003	8:30	7.3	5.6	1.7	2000	29	110.7		0.12				8300/11900	110.7	0.01334
	16:30	7.3	5.9			29			1.2				R = 0.697		
	23:00	7.4	6.1			29			0.68						
4/25/2003	9:00	7.4	6.2	1.6	2000	29	110.7		0.14					110.6	0.01333
	16:30	7.3	5.9			28			0.32						
	23:00	7.4	5.8			28			0.68						
4/26/2003	8:30	7.3	6.1	1.4	2000	28	110.7		0.24					110.6	0.01332
	18:00	7.3	5.9			28			0.42						
4/27/2003	9:30	7.3	6.2	2.2	2000	28	110.7		0.16					110.7	
	18:00	7.4	5.9			28			0.76						
4/28/2003	8:30	7.3	5.7	1.8	2000	28	110.7		0.12					110.7	
	16:30	7.3	5.8			29			0.83						
	23:00	7.3	6.3			29			0.46						
4/29/2003	9:00	7.4	6.9	2.3	2000	29	110.7	38	0.1	440	6	4		110.7	
	17:00	7.4	6.6			29			0.62						
	23:00	7.4	5.6			29			0.23						
4/30/2003	8:30	7.3	5.9	2.2	2000	29	110.7		0.08					110.7	0.01401
	18:00	7.4	6.1			28			0.26						
	23:00	7.3	6.2			28			0.32						
5/1/2003	8:30	7.3	5.9	1.9	2000	28	110.7		0.07				7900/11100	110.7	0.01401
	16:30	7.3	5.6			28			0.13				R = 0.71		
	23:00	7.4	5.9			28			0.24						
5/2/2003	8:30	7.3	6.1	2.1	2000	29	110.7		0.1					110.6	0.01400
	18:00	7.4	6.2			29			0.14						
	23:00	7.3	5.9			28			0.22						
5/3/2003	9:00	7.3	5.8	2.2	2000	28	110.7		0.08					110.7	
	17:00	7.3	6.1			28			0.12						

TABLE 5.13

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR THE REACTOR SBR-1
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Groundwater (ML)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
5/4/2003	9:00	7.4	5.9	1.8	2000	29	110.7		0.05					110.7	0.01419
	17:00	7.3	6.2			29			0.16						
	23:00	7.4	5.7			28			0.18						
5/5/2003	9:00	7.3	5.6	1.3	2000	28	110.7		0.1				7800/11600	110.6	0.01418
	17:00	7.3	5.4			28			0.14				R = 0.672		
	23:00	7.4	5.9			29			0.2						
5/6/2003	8:30	7.4	6.3	2.1	2000	29	110.7	46	0.09	470	6	5		110.7	0.01419
	16:30	7.3	5.9			29			0.1						
	23:00	7.4	5.6			29			0.22						
5/7/2003	9:00	7.4	5.9	1.8	2000	28	108.0		0.08					110.7	
	17:00	7.3	6.1			28			0.2						
	23:00	7.4	6.3			28			0.26						
5/8/2003	9:00	7.3	5.9	1.9	2000	28	108.0		0.11					108.0	
	16:30	7.4	5.3			29			0.28						
	23:00	7.4	5.1			29			0.31						
5/9/2003	9:00	7.4	4.3	1.3	2000	29	108.0		0.65					107.5	
	17:00	7.3	5.8			29			0.26						
	23:00	7.4	5.9			28			0.29						
5/10/2003	10:00	7.4	6.2	1.9	2000	28	108.0		0.15					108.5	
	23:00	7.3	6.4			30			0.27						
5/11/2003	10:30	7.4	5.9	2.2	2000	29	108.0		0.18					108.0	0.01440
	22:30	7.4	6.1			29			0.78						
5/12/2003	8:30	7.3	6.2	1.9	2000	29	108.0		0.37				7500/10800	107.8	0.01437
	17:00	7.4	5.8			28			0.43				R = 0.694		
	23:00	7.3	6.1			28			0.31						
5/13/2003	9:00	7.4	6.2	2.1	2000	30	108.0		0.22					108.2	0.01442
	17:00	7.4	7.2			28			1.2						
	23:00	7.4	5.7			28			0.56						

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR THE REACTOR SBR-1
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (Std Un)	DO (mgO2/L)	DO(15 min)	Groundwater (ML)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
5/14/2003	9:00	7.4	7.4	3.1	2000	29	108.0	0.09						108.1	0.01502
	15:00	7.4	5.9			29		0.24							
	23:00	7.4	6.2			28		0.31							
5/15/2003	8:30	7.4	6.4	1.9	2000	28	108.0	0.08					7200/9800	108.0	0.01500
	16:30	7.3	5.9			28		0.09					R = 0.734		
	23:00	7.4	6.1			29		0.29							
5/16/2003	8:30	7.3	5.9	1.8	2000	29	108.0	0.1						108.0	0.01500
	16:30	7.4	6.3			29		0.1							
	23:00	7.4	5.8			29		0.25							
5/17/2003	10:00	7.4	4.4	2.3	2000	28	86.7	0.12						108.0	0.01500
	23:00	7.3	5.7			28		0.28							
5/18/2003	11:00	7.4	6.1	2.2	2000	29	86.7	0.06						86.7	
	23:00	7.4	5.9			29		0.23							

TABLE 5.14

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Groundwater (mL)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
4/2/2003	9:00	7.4	5.8	2.8	2000	29	96.0		0.14					95.9	0.01142
	17:00	7.6	6.5			29			0.22						
	23:00	7.5	6.6			29			0.62						
4/3/2003	9:00	7.4	7.3	3.6	2000	28	96.0	65	0.21	355	12	9	9400/14500		
	17:00	7.5	7.5			28			0.32				R = 0.648		
	23:00	7.5	7.4			28			0.46						
4/4/2003	9:00	7.4	7.2	3.4	2000	29	96.0		0.22					96.0	0.01143
	15:30	7.4	7.6			28			0.8						
	23:00	7.5	6.9			29			0.14						
4/5/2003	9:00	7.4	7.4	3.7	2000	28	96.0		0.22					96.0	0.01143
	17:00	7.5	7.2			29			1.8						
	23:00	7.5	7.6			28			0.28						
4/6/2003	9:00	7.4	7.4	3.2	2000	29	96.0		0.17					96.1	0.01067
	17:00	7.4				28			0.96						
	23:00	7.5	7.3			28			1.7						
4/7/2003	9:00	7.5	7.8	3.3	2000	28	96.0		0.17				9000/13900	96.0	0.01067
	16:30	7.4	6.9			28			0.24				R = 0.647		
	23:00	7.5	7.4			28			1.6						
4/8/2003	8:30	7.4	7.2	2.9	2000	28	96.0		0.12					96.1	0.01067
	17:00	7.4	7.4			29			2.7						
	23:00	7.4	7.2			28			1.4						
4/9/2003	9:00	7.5	7.6	3.2	2000	28	96.0	71	0.14	360	14	11		96.0	0.01043
	17:30	7.4	7.4			28			0.11						
	23:00	7.5	7.2			28			0.35						
4/10/2003	9:00	7.5	7.3	3.1	2000	28	96.0		0.16				9200/14500	96.0	0.01043
	17:00	7.5	7.8			28			2.8				R = 0.634		
	23:00	7.4	6.9			29			1.1						
4/11/2003	9:00	7.5	7.4	2.9	2000	28	101.3		0.14					96.0	0.01044
	16:30	7.4	7.2			29			1.3						
	23:00	7.4	7.4			28			0.68						
4/12/2003	8:30	7.4	7.2	2.8	2000	29	101.3		0.05					101.4	0.00930
	17:00	7.5	7.6			28			0.82						
	23:00	7.5	6.9			29			0.63						

TABLE 5.14

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Groundwater (mL)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
4/13/2003	9:00	7.4	7.4	2.8	2000	28	101.3		0.14				10900/16500	101.2	0.00929
	17:30	7.5	7.4			28			0.52				R = 0.660		
	23:00	7.4	7.2			28			0.43						
4/14/2003	9:00	7.4	7.6	2.6	2000	28	101.3		0.12					101.4	0.00930
	17:00	7.4	7.4			28			0.56						
	23:00	7.5	7.2			28			0.44						
4/15/2003	9:00	7.4	7.3	2.9	2000	29	101.3		0.14					101.3	
	17:30	7.5	7.6			28			0.18						
	23:00	7.5	7.4			29			0.68						
4/16/2003	9:00	7.4	7.2	2.6	2000	28	101.3		0.12					101.3	0.01045
	17:00	7.5	7.3			29			2.8						
	23:00	7.4	7.6			28			1.2						
4/17/2003	9:30	7.4	7.4	2.4	2000	29	101.3		0.13				9700/14800	101.3	0.01045
	16:30	7.4	7.2			28			1.6				R = 0.655		
	23:00	7.5	7.3			29			2.1						
4/18/2003	9:30	7.4	7.6	2.8	2000	28	101.3		0.12					101.3	0.01045
	17:00	7.4	7.4			28			0.15						
	23:00	7.4	7.2			28			0.36						
4/19/2003	9:00	7.4	7.4	2.4	2000	29	101.3		0.1					101.4	
	16:00	7.4	7.2			28			0.18						
	23:00	7.4	7.3			29			0.29						
4/20/2003	8:30	7.4	7.6	2.5	2000	28	101.3		0.12					101.3	0.01078
	16:30	7.5	7.4			29			0.28						
	23:00	7.4	6.8			28			0.32						
4/21/2003	8:30	7.5	7.1	2.1	2000	29	105.3	48	0.09	450	16	11	9400/14200	101.4	0.01078
	16:00	7.4	6.8			29			0.14				R = 0.662		
	23:00	7.4	6.2			28			0.32						
4/22/2003	9:00	7.4	6.6	1.9	2000	28	105.3		0.15					105.3	0.01120
	16:00	7.4	6.2			28			0.18						
	23:00	7.4	6.2			29			0.28						

TABLE 5.14

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Groundwater (mL)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
4/23/2003	8:30	7.4	6.6	1.6	2000	28	105.3		0.13					105.4	0.01145
	16:30	7.5	6.5			29			0.15						
	23:00	7.4	6.3			28			0.22						
4/24/2003	8:30	7.4	5.9	1.9	2000	29	105.3		0.14				9200/14100	105.3	0.01145
	16:30	7.3	5.8			28			0.68				R = 0.652		
	23:00	7.3	5.6			29			0.42						
4/25/2003	9:00	7.4	5.4	2.1	2000	28	105.3		0.24					105.2	0.01144
	16:30	7.4	6.3			28			1.5						
	23:00	7.4	6.2			28			0.72						
4/26/2003	8:30	7.5	6.6	2.5	2000	28	105.3		0.14					105.4	0.01146
	18:00	7.4	6.5			29			0.64						
4/27/2003	9:30	7.5	6.3	2.2	2000	28	105.3		0.11					105.4	
	18:00	7.4	6.2			28			0.68						
4/28/2003	8:30	7.4	5.9	2.1	2000	28	105.3		0.14					105.3	
	16:30	7.3	6.1			28			1.1						
	23:00	7.4	6.4			29			0.82						
4/29/2003	9:00	7.4	5.7	1.9	2000	29	105.3	36	0.09	460	9	6		105.4	
	17:00	7.3	6.2			28			0.56						
	23:00	7.4	6.6			29			0.32						
4/30/2003	8:30	7.4	6.5	2.3	2000	28	105.3		0.08					105.3	0.01225
	18:00	7.3	6.3			29			0.16						
	23:00	7.3	5.9			28			0.29						
5/1/2003	8:30	7.4	5.8	2.2	2000	28	105.3		0.09				8600/12800	105.3	0.01225
	16:30	7.4	5.6			28			0.16				R = 0.671		
	23:00	7.4	5.4			28			0.28						
5/2/2003	8:30	7.4	5.2	2.4	2000	29	105.3		0.12					105.3	0.01224
	18:00	7.3	5.6			28			0.22						
	23:00	7.3	5.5			28			0.29						
5/3/2003	9:00	7.4	5.3	1.9	2000	29	105.3		0.09					105.4	
	17:00	7.4	5.9			29			0.18						

TABLE 5.14

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Groundwater (mL)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
5/4/2003	9:00	7.2	5.8	2.2	2000	29	105.3		0.14					105.3	0.01253
	17:00	7.3	5.6			30			0.1						
	23:00	7.4	5.4			29			0.26						
5/5/2003	9:00	7.4	6.3	1.8	2000	30	105.3		0.17				8400/12500	105.3	0.01254
	17:00	7.4	6.2			30			0.12				R = 0.672		
	23:00	7.5	6.6			29			0.23						
5/6/2003	8:30	7.4	6.5	2.3	2000	29	105.3	34	0.08	490	10	7		105.4	0.01255
	16:30	7.3	6.2			28			0.11						
	23:00	7.3	5.9			29			0.32						
5/7/2003	9:00	7.4	6.3	2.1	2000	29	105.3		0.12					105.3	
	17:00	7.4	6.1			29			0.44						
	23:00	7.4	5.8			30			0.29						
5/8/2003	9:00	7.4	6.4	2.2	2000	29	104.0		0.1					105.4	
	16:30	7.5	6.2			29			0.28						
	23:00	7.5	6.1			29			0.36						
5/9/2003	9:00	7.4	5.8	1.9	2000	28	104.0		0.16					103.9	
	17:00	7.3	5.9			29			0.24						
	23:00	7.3	5.7			29			0.31						
5/10/2003	10:00	7.4	5.8	1.8	2000	29	104.0		0.22					103.9	
	23:00	7.3	5.6			29			0.29						
5/11/2003	10:30	7.3	5.5	1.6	2000	29	104.0		0.17					104.1	0.01317
	22:30	7.4	5.8			29			0.48						
5/12/2003	8:30	7.4	5.3	1.5	2000	28	104.0		0.25				7900/11400	103.9	0.01315
	17:00	7.4	5.2			29			0.62				R = 0.692		
	23:00	7.4	4.9			29			0.38						
5/13/2003	9:00	7.4	4.6	1.3	2000	30	104.0		0.18					104.1	0.01317
	17:00	7.3	6.3			29			1.2						
	23:00	7.3	5.8			29			0.67						
5/14/2003	9:00	7.4	6.4	2.2	2000	30	104.0		0.46					103.7	0.01365
	16:00	7.3	5.7			29			1.3						
	23:00	7.3	5.9			29			0.68						

TABLE 5.14

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION, HRT = 7.5 DAYS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH_3-N nitrif	NH_3-nitr/VSS (mg/L)
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Groundwater (mL)	Temperature(C)		COD	NH_3-N	NO_3-N	TSS	VSS			
5/15/2003	8:30	7.3	5.2	2.1	2000	29	104.0		0.3				7600/10600	104.2	0.01371
	16:30	7.3	5.1			29			0.16				R = 0.716		
	23:00	7.4	5.8			29			0.32						
5/16/2003	8:30	7.3	6.4	2.6	2000	30	104.0		0.18					104.1	0.01370
	16:30	7.3	6.2			30			0.33						
	23:00	7.4	6.1			29			0.29						
5/17/2003	10:00	7.4	5.8	2.7	2000	29	77.3		0.12					104.1	
	23:00	7.3	6.1			29			0.28						
5/18/2003	11:00	7.3	5.8	1.9	2000	29	77.3		0.12					77.3	
	23:00	7.4	6.4			30			0.31						

TABLE 5.15

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1 OPTIMIZATION AT HRT = 5 DAYS, T = 30°C AND PROLONGED FEED WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE WAUKEGAN, ILLINOIS

Date	*Time*	*Operational Parameters*					*Analytical Data*		
		pH (St Un)	*DO (mgO_2/L)*	*DO(15 min)*	*Feed (ml)*	*Temp*	*TKN load (mg/L)*	*MLVSS/MLTSS Ratio*	*NH_3-N in Mixed Liquor*
May-27	8:30	7.3	5.9	2.2	2100	29	91.0	6700/9600	0.11
	18:00	7.5	5.9			30		R = 0.698	0.35
	23:00	7.6	5.8			29			0.22
May-28	9:00	7.5	6.3	2.8	2100	29	91.0		0.14
	17:00	7.6	6.4			30			0.2
	23:00	7.5	5.9			29			0.28
May-29	8:00	7.4	6.1	2.6	2200	30	95.3		0.14
	16:30	7.4	6.1			28			0.64
	23:00	7.3	5.9			29			0.43
May-30	8:30	7.3	6.3	2.9	2300	29	99.7	7200/10700	0.11
	17:00	7.3	6.1			29		R = 0.673	0.61
	23:00	7.5				30			0.32
May-31	10:00	7.6	5.9	2.4	2300	28	99.7		0.71
	23:00	7.4	6.3			29			0.23
Jun-01	9:00	7.3	6.1	2.8	2400	29	104.0		0.06
	23:00	7.3	5.9			29			0.19
Jun-02	9:00	7.3	5.8	2.1	2500	30	108.3		0.07
	18:00	7.5	6.1			29			0.09
	23:00	7.4	5.9			30			0.14
Jun-03	9:00	7.4	6.3	2.4	2600	28	112.7	7100/10500	0.04
	18:00	7.3	6.1			29		R = 0.676	0.12
	23:00	7.3	5.9			29			0.19

TABLE 5.15

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1 OPTIMIZATION AT HRT = 5 DAYS, T = 30°C AND PROLONGED FEED WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					Analytical Data		
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Feed (ml)	Temp	TKN load (mg/L)	MLVSS/MLTSS Ratio	NH_3-N in Mixed Liquor
Jun-04	8:30	7.3	6.2	1.9	2700	29	117.0		0.07
	17:00	7.3	6.4			28			0.05
	23:00	7.3	6.1			29			0.09
Jun-05	9:00	7.5	5.7	1.8	2800	29	121.3		0.08
	17:00	7.3	6.1			28			0.82
	23:00	7.3	5.9			29			0.28
Jun-06	9:30	7.3	5.8	1.6	3000	29	130.0		1.2
	17:00	7.5	6.1			29			0.8
	23:00	7.3	5.9			28			0.16
Jun-07	10:00	7.3	6.1	1.8	3000	28	130.0		0.68
	23:00	7.3	5.9			29			0.46
Jun-08	9:00	7.5	5.8	1.5	3000	29	124.0		0.07
	23:00	7.4	6.3			29			0.18
Jun-09	8:30	7.4	5.9	1.4	3000	28	124.0	7300/10800	0.96
	17:00	7.3	6.1			28		R = 0.675	0.05
	23:00	7.5	5.9			28			0.25
Jun-10	8:30	7.4	6.1	1.3	3000	29	124.0		0.06
	17:00	7.4	6.2			30			0.08
	23:00	7.6	5.9			29			0.11

TABLE 5.16

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2 OPTIMIZATION AT HRT = 5 DAYS, T = 30°C AND PROLONGED FEED WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE WAUKEGAN, ILLINOIS

Date	*Time*	*Operational Parameters*					*TKN load (mg/L)*	*Analytical Data*	
		pH (St Un)	*DO (mgO_2/L)*	*DO(15 min)*	*Groundwater (mL)*	*Temperature(C)*		*MLVSS/MLTSS Ratio*	*NH3-N in Mixed Liquor*
May-27	8:30	7.4	6.2	2.6	2000	29	77.3	R = 0.736	0.1
	18:00	7.5	5.9			30			0.22
	23:00	7.5	5.8			29			0.29
May-28	9:00	7.4	6.4	2.9	2000	29	77.3		0.14
	17:00	7.5	5.7			30			0.2
	23:00	7.3	5.9			31			0.16
May-29	8:00	7.4	5.8	2.4	2100	33	81.2		0.14
	16:30	7.4	5.7			29			0.18
	23:00	7.3	5.9			29		6900/9900	0.26
May-30	8:30	7.3	5.8	2.2	2100	29	81.2	R = 0.697	0.21
	17:00	7.3	6.4			29			0.35
	23:00	7.3				29			0.19
May-31	10:00	7.3	5.9	2.1	2100	30	81.2		2.8
	23:00	7.4	5.8			29			0.16
Jun-01	9:00	7.3	6.4	2.7	2100	29	81.2		0.08
	23:00	7.3	5.7			30			0.21
Jun-02	9:00	7.4	5.9	2.3	2100	30	81.2		0.11
	18:00	7.5	6.2			29			0.41
	23:00	7.4	6.1			29		6700/9500	0.32
Jun-03	9:00	7.5	5.9	2.5	2400	29	92.8	R = 0.726	0.1
	18:00	7.3	6.2			30			0.08
	23:00	7.4	6.3			29			0.16

TABLE 5.16

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
OPTIMIZATION AT HRT = 5 DAYS, T = 30°C AND PROLONGED FEED
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Analytical Data	
		pH (St Un)	DO (mgO_2/L)	DO(15 min)	Groundwater (mL)	Temperature(C)		MLVSS/MLTSS Ratio	NH3-N in Mixed Liquor
Jun-04	8:30	7.4	6.2	2.7	2400	29	92.8		0.08
	17:00	7.5	5.9			29			0.06
	23:00	7.4	6.1			29			0.12
Jun-05	9:00	7.4	6.2	2.2	2400	28	92.8		0.09
	17:00	7.3	5.7			29			2.9
	23:00	7.3	5.9			29			0.22
Jun-06	8:30	7.4	5.8	1.5	2700	29	104.4		0.12
	17:00	7.3	6.4			28			5.9
	23:00	7.3	5.7			29			0.28
Jun-07	10:00	7.4	5.9	1.6	2800	29	108.3		0.68
	23:00	7.5	5.8			28			0.32
Jun-08	9:00	7.4	6.4	1.9	2800	29	108.3		0.08
	23:00	7.4	5.7			29		7200/10600	0.26
Jun-09	8:30	7.3	5.9	1.7	3000	29	116.0	R = 0.679	0.12
	17:00	7.3	5.7			28			0.5
	23:00	7.4	5.9			29			0.6
Jun-10	8:30	7.5	5.7	1.8	2800	28	108.3		0.8
	10:00	7.5	6.2	3.6		29			0.6
	17:30	7.4	5.9			29			0.5
	22:00	7.5	5.8			29			2.2
Jun-11	8:30	7.4	6.2	2.4	3000	30	116.0		0.13

TABLE 5.17

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1
STEADY STATE OPERATION AT 5 DAYS HRT, 30°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	Comments
		pH (St Un)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS				
Jun-02	9:00	7.3	5.8	2.1	2500	30	108.3		0.07					104.0	0.01465	
	18:00	7.3	6.1			29			0.09							
	23:00	7.4	5.9			30			0.14							
Jun-03	9:00	7.4	6.3	2.4	2600	28	112.7		0.04				7100/10500	108.4	0.01526	Air flow adjusted
	18:00	7.3	6.1			29			0.12				R = 0.676			2 diffusers replaced
	23:00	7.3	5.9			29			0.19							
Jun-04	8:30	7.3	6.2	1.9	2700	29	117.0		0.07					112.6	0.01586	
	17:00	7.3	6.4			28			0.05							
	23:00	7.3	6.1			29			0.09							
Jun-05	9:00	7.3	5.7	1.8	2800	29	121.3		0.08					117.0	0.01648	
	17:00	7.3	6.1			28			0.82							
	23:00	7.3	5.9			29			0.28							
Jun-06	9:30	7.3	5.8	1.6	3000	29	130.0		1.2					120.2		100 % feed at 5 HRT
	17:00	7.3	6.1			29			0.8							
	23:00	7.3	5.9			28			0.16							
Jun-07	10:00	7.3	6.1	1.8	3000	28	130.0		0.68					130.5		
	23:00	7.3	5.9			29			0.46							
Jun-08	9:00	7.3	5.8	1.5	3000	29	124.0		0.07					130.6	0.01789	
	23:00	7.4	6.3			29			0.18							
Jun-09	8:30	7.4	5.9	1.4	3000	28	124.0		0.96				7300/10800	123.1	0.01686	
	17:00	7.3	6.1			28			0.05				R = 0.675			
	23:00	7.3	5.9			28			0.25							
Jun-10	8:30	7.3	6.1	1.3	3000	29	124.0		0.06					124.9	0.01711	1 L ML taken to R # 2
	17:30	7.4	5.9			28			0.08							1 L make up water added
	22:00	7.4	5.8			28			0.09							
Jun-11	8:30	7.3	6.5	1.8	3000	29	124.0		0.06					124.0		
	5:30	7.3	6.1			28			0.05							
	23:00	7.3	5.9			28			0.09							
Jun-12	8:30	7.3	5.8	1.6	3000	29	124.0		0.08					124.0	0.01722	
	17:00	7.5	6.1			29			0.09							
	22:30	7.4	5.9			29			0.07							
Jun-13	9:00	7.4	6.3	1.9	3000	28	124.0		0.06				7200/9500	124.0	0.01723	
	17:00	7.3	6.1			28			0.09				R = 0.757			
	23:00	7.3	5.9			28			0.08							
Jun-14	8:30	7.3	6.2	1.9	3000	29	124.0		0.07					124.0	0.01722	
	23:00	7.5	6.4			28			0.09							
Jun-15	9:00	7.4	6.1	2.1	3000	28	124.0		0.06					124.0	0.01722	
	22:30	7.4	5.7			28			0.08							
Jun-16	8:30	7.3	6.1	1.9	3000	29	124.0		0.05					124.0		
	17:00	7.3	5.9			29			0.06							
	23:30	7.3	5.8			29			0.08							
Jun-17	8:30	7.3	6.1	1.8	3000	28	104.0		0.04					124.0	0.02000	250 ml of ML wasted for analyses
	17:00	7.3	5.9			28			0.09							Air flow adjusted
	22:30	7.5	5.8			28			0.08							
Jun-18	8:30	7.3	5.9	1.6	3000	29	104.0		0.06				6200/9050	104.0	0.01677	
	17:00	7.4	5.9			28			0.14				R = 0.685			
	22:30	7.4	5.8			29			0.07							
Jun-19	8:30	7.3	5.9	1.8	3000	29	104.0		0.05					104.0	0.01678	
	17:00	7.3	5.9			29			0.06							
	22:30	7.3	5.8			28			0.09							
Jun-20	8:30	7.4	5.9	1.7	3000	28	104.0		0.08					104.0	0.01677	250 ml of ML wasted for analyses
	17:30	7.4	6.2			29			0.04							
	23:00	7.3	5.8			29			0.07							
Jun-21	10:00	7.3	6.1	1.9	3000	29	104.0		0.05					104.0		250 ml of ML wasted for analyses
	23:00	7.3	5.7			28			0.06							
Jun-22	9:00	7.3	6.1	1.8	3000	28	104.0		0.03					104.0		250 ml of ML wasted for analyses
	23:00	7.3	5.9			28			0.05							

TABLE 5.17

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1
STEADY STATE OPERATION AT 5 DAYS HRT, 30°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)					MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	Comments
		pH (S.U.)	DO (mgO2/L)	DO (15 min	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Jun-23	9:00	7.4	6	2.1	3000	29	158.0		0.04					104.0	0.01857	200 ml of ML wasted
	17:00	7.4	5.9			29			0.06							
	22:30	7.5	6.1			30			0.04							
Jun-24	9:00	7.4	5.8	1.8	3000	29	158.0		0.05					158.0	0.02821	200 ml of ML wasted for analyses
	17:00	7.4	5.9			30			0.04							
	22:30	7.3	5.9			30			0.04							
Jun-25	9:00	7.3	5.8	1.6	3000	30	158.0		0.05					158.0	0.02821	200 ml of ML wasted
	17:00	7.3	5.9			29			0.06							
	22:30	7.3	5.9			30			0.03							
Jun-26	9:00	7.3	5.8	1.7	3000	29	158.0		0.05				5600/7500	158.0	0.02821	200 ml of ML wasted
	17:00	7.5	5.9			29			0.04				R = 0.746			
	22:30	7.3	6.2			30			0.06							
Jun-27	9:00	7.4	5.8	1.6	3000	29	158.0		0.04					158.0		250 ml of ML wasted for analyses
	17:00	7.4	5.9			30			0.05							
	22:30	7.3	5.9			30			0.05							
Jun-28	10:00	7.3	5.8	1.8	3000	30	158.0		0.04					158.0		250 ml of ML wasted for analyses
	23:00	7.3	5.9			29			0.04							
Jun-29	8:30	7.4	5.9	1.6	3000	29	158.0		0.05					158.0	0.02926	200 ml of ML wasted
	22:30	7.4	5.8			30			0.06							
Jun-30	9:00	7.3	5.9	1.6	3000	29	158.0		0.03				5400/7200	158.0	0.02926	
	17:00	7.3	5.9			30			0.05				R = 0.75			
	22:30	7.3	5.8			30			0.04							
Jul-01	8:30	7.3	5.9	1.7	3000	30	158.0		0.06					158.0	0.02925	200 ml of ML wasted
	22:30	7.3	5.9			29			0.04							
Jul-02	9:00	7.4	5.8	1.8	3000	30	158.0		0.03					158.0	0.02926	
	17:00	7.4	5.9			30			0.04							
	22:30	7.4	6.2			30			0.07							
Jul-03	9:00	7.3	5.8	1.7	3000	30	158.0		0.03					158.0		200 ml of ML wasted
	17:00	7.3	5.8			30			0.03							
	22:30	7.3	5.9			30			0.08							
Jul-04	8:30	7.4	5.9	1.6	3000	30	158.0		0.02					158.0		
	17:00	7.4	5.8			29			0.03							
	23:00	7.4	5.9			30			0.05							
Jul-05	9:00	9.2	5.9	2.5	1000	30	52.7		1.5					156.5	0.03261	pH probe mulfunction, soda ash overfeed
	22:30	7.4	6.3			31			0.08							raw feed stopped, feed with water
Jul-06	8:30	7.3	5.8	2.1	2000	30	105.3		0.04					54.1	0.01128	pH adjusted with H3PO4
	23:00	7.3	6.1			29			0.05							Foaming
Jul-07	8:30	7.9	5.9	1.7	1000	30	39.3		1.2				4800/6300	104.2	0.02170	raw feed stopped, feed with water
	14:00	8.1	6.1			30			46.5				R = 0.761			pH adjusted with H3PO4
	17:30	8.2	5.9			30			4.8							pH adjusted with H3PO4
	22:30	7.6	5.9			30			1.2							
Jul-08	9:00	7.8	6.3	3.2	1000	30	39.3		0.36					42.9	0.00894	pH adjusted with H3PO4
	17:00	7.9	5.9			30			1.6							feed reduced
	22:30	7.8	6.1			30			0.43							5 g PAC added
Jul-09	8:30	8.6	5.9	2.9	1000	29	39.3		0.14					40.6		pH adjusted with H3PO4
	17:00	8.2	6			30			0.78							feed reduced
	23:00	7.6	5.9			30			0.83							
Jul-10	8:30	7.6	5.8	2.8	1000	30	39.3		2.3					40.0		feed reduced
	17:00	7.5	5.9			30			0.8							
	22:00	7.7	5.8			30			0.3							
Jul-11	9:00	7.3	5.9	3.3	1100	30	43.3		1.2					37.8		feed increased
	17:30	7.4	5.9			30			0.2							
	22:30	7.5	5.8			30			0.6							
Jul-12	9:00	7.4	5.9	2.9	1200	30	47.2		0.08					42.3	0.00829	5 g PAC added
	22:00	7.3	5.8			29			0.16							pH adjusted with H3PO4
Jul-13	9:00	7.3	5.9	2.8	1200	30	47.2		0.36				5100/7100	47.2	0.00925	
	22:00	7.4	5.9			30			0.21				R = 0.718			

TABLE 5.17

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1
STEADY STATE OPERATION AT 5 DAYS HRT, 30°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	Comments
		pH (Su Un)	DO (mgO2/L)	DO (15 min.	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS				
Jul-14	8:30	7.3	5.8	2.7	1300	30	51.1		0.22					47.2	0.00925	
	17:00	7.4	5.9			31			0.09							
	23:00	7.3	6.2			30			0.07							
Jul-15	8:30	7.3	5.8	2.5	1400	30	55.1		0.11					51.2		
	17:00	7.6	5.9			30			0.1							
	23:00	7.6	5.8			30			0.3							
Jul-16	9:00	7.5	5.9	2.2	1600	30	62.9		0.16					55.0	0.00834	15 g PAC added
	17:00	7.7	5.8			30			0.13							
	23:00	7.3	5.9			30			0.14							
Jul-17	9:00	7.4	5.9	2.2	1800	29	70.8		0.18				6600/8700	62.9	0.00953	15 g PAC added
	17:00	7.5	5.8			30			0.09				R = 0.758			
	23:00	7.6	5.9			30			0.21							
Jul-18	9:00	7.5	5.8	2.1	2000	30	78.7		0.08					70.9	0.01074	15 g PAC added
	17:00	7.7	5.9			30			0.09							
	23:00	7.6	5.9			30			0.12							
Jul-19	9:00	7.6	6.1	2.2	2200	30	86.5		0.06					78.7		10 g PAC added
	22:00	7.5	6.1			30			0.09							1 L ML exchange with R# 2
Jul-20	8:00	7.7	5.8	2.1	2300	31	90.5		0.02					86.6	0.01056	1 L ML exchange with R# 2
	22:00	7.3	5.9			30			0.08							
Jul-21	8:30	7.4	5.8	1.9	2500	30	98.3		0.04				8200/10500	90.4	0.01103	1 L ML exchange with R# 2
	17:00	7.3	5.8			30			0.08				R = 0.780			
	23:00	7.4	5.9			25			0.06							
Jul-22	9:00	7.6	5.5	1.4	2700	30	147.6		0.04					98.3	0.01199	Heater replaced
	17:00	7.3	6.5			30			0.03							Aerators replaced
	23:00	7.3	6.6			30			0.06							
Jul-23	9:00	7.4	6.8	2.5	3000	30	164.0		0.03					147.6	0.01800	Air flow adjustec, DO calibrated
	17:00	7.3	6.4			30			0.04							
	23:00	7.4	6.6			30			0.02							
Jul-24	9:00	7.3	6.4	2.3	3000	30	164.0		0.08					164.0	0.01906	
	17:00	7.6	7.6			30			0.04							
	23:00	7.6	7.8			30			0.02							
Jul-25	9:00	7.5	7.7	3.2	3000	30	164.0		0.08				8600/10700	164.0	0.01907	Wasted 150 ml M/L
	17:00	7.7	7.5			30			0.04				R = 0.803			
	23:00	7.3	7.3			30			0.08							
Jul-26	9:00	7.4	7.8	3.8	3000	30	134.0		0.06					164.0	0.01907	Wasted 150 ml M/L
	22:00	7.6	7.7			30			0.08							
Jul-27	9:00	7.6	7.5	3.4	3000	30	134.0		0.04					134.0	0.01558	Wasted 150 ml M/L
	22:00	7.5	7.5			30			0.02							
Jul-28	8:30	7.7	7.3	3.3	3000	30	134.0		0.08					134.0		Wasted 150 ml M/L
	17:00	7.3	7.8			30			0.04							
	23:00	7.4	7.7			30			0.08							
Jul-29	9:00	7.3	7.5	3.6	3000	30	134.0		0.06					134.0	0.01696	Wasted 200 ml M/L
	17:00	7.3	6.8			31			0.08							
	22:30	7.3	6.4			30			0.12							
Jul-30	9:00	7.4	6.6	3.1	3000	30	134.0		0.1				7900/10200	134.0	0.01696	Wasted 100 ml M/L
	17:00	7.3	6.4			30			0.06				R = 0.775			
	22:30	7.4	7.6			30			0.09							

TABLE 5.18

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION AT 25°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	Comments
		pH (St Un)	DO (mg/L)	DO (15 min	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS			
Jun-02	9:00	7.4	5.9	2.3	2100	30	81.2		0.11					81.2	0.01211	Feed changed to 3 cycles/day
	18:00	7.5	6.2			29			0.41							
	23:00	7.4	6.1			29			0.32							
Jun-03	9:00	7.5	5.9	2.5	2400	29	92.8		0.1				6700/9500	81.2	0.01212	
	18:00	7.3	6.2			30			0.08				R = 0.726			
	23:00	7.4	6.3			29			0.16							
Jun-04	8:30	7.4	6.2	2.7	2400	29	92.8		0.08					92.8	0.01385	
	17:00	7.5	5.9			29			0.06							
	23:00	7.4	6.1			29			0.12							
Jun-05	9:00	7.4	6.2	2.2	2400	28	92.8		0.09					92.8	0.01385	
	17:00	7.3	5.7			29			2.9							
	23:00	7.3	5.9			29			0.22							
Jun-06	8:30	7.4	5.8	1.5	2700	29	104.4		0.12					92.8		
	17:00	7.3	6.4			28			5.9							
	23:00	7.3	5.7			29			0.28							
Jun-07	10:00	7.4	5.9	1.6	2800	29	108.3		0.68					103.8		
	23:00	7.5	5.8			28			0.32							
Jun-08	9:00	7.4	6.4	1.9	2800	29	108.3		0.08					108.9	0.01512	
	23:00	7.4	5.7			29			0.26							
Jun-09	8:30	7.3	5.9	1.7	3000	29	116.0		0.12				7200/10600	108.2	0.01503	
	17:00	7.3	5.7			28			10.5				R = 0.679			
	23:00	7.4	5.9			29			22.5							
Jun-10	8:30	7.5	5.7	1.8	2800	28	108.3		2.8					113.3	0.01574	
	10:00	7.5	6.2	3.6		29			32.6							Feed discont, 2 1. ML taken to R3
	17:30	7.4	5.9			29			10.5							Added: 1L ML from R1 and 1L water
	22:00	7.5	5.8			29			2.2							
Jun-11	8:30	7.4	6.2	2.4	3000	28	116.0		0.13					110.9		
	5:30	7.5	4.6			29			11.3							
	23:00	7.4	5.9			29			0.9							
Jun-12	8:30	7.5	4.9	1.5	3000	28	116.0		0.07					116.1	0.01758	
	17:00	7.4	5.7			29			7.9							
	22:30	7.5	5.9			28			0.09							
Jun-13	9:00	7.4	5.8	1.6	3000	29	116.0		0.07				6600/9200	116.0	0.01758	
	17:00	7.5	5.7			29			4.8				R = 0.717			
	23:00	7.3	5.9			29			0.08							
Jun-14	8:30	7.4	5.8	1.8	3000	28	116.0		0.1					116.0	0.01757	
	23:00	7.4	5.7			29			0.09							
Jun-15	9:00	7.5	5.9	1.6	3000	28	116.0		0.07					116.0	0.01758	
	22:30	7.4	5.8			29			0.12							
Jun-16	8:30	7.4	5.7	1.7	3000	28	116.0		0.06					116.0		
	17:00	7.3	5.9			29			5.1							
	23:30	7.3	5.8			29			0.11							
Jun-17	8:30	7.4	6.1	1.9	3000	29	98.0		0.05					116.0	0.01871	250 ml ML wasted for analyses
	17:30	7.3	5.7			28			5.4							Air flow adjusted
	22:30	7.3	5.9			29			0.08							
Jun-18	8:30	7.4	5.8	1.4	3000	28	98.0		0.07				6200/9100	98.0	0.01580	
	17:00	7.4	6.2			29			0.12				R = 0.681			
	22:30	7.5	6.1			29			0.09							
Jun-19	8:30	7.3	6.2	2.1	3000	29	98.0		0.04					98.0	0.01581	
	17:00	7.4	5.9			28			0.07							
	22:30	7.4	5.8			29			0.08							

TABLE 5.18

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION AT 25°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	Comments
		pH (St Un)	DO (mg/L)	DO (15 min.	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS			
Jun-20	8:30	7.4	5.7	1.6	3000	28	98.0		0.05					98.0	0.01580	250 ml ML wasted for analyses
	17:30	7.5	5.9			29			6.5							
	23:00	7.3	5.9			29			0.07							
Jun-21	10:00	7.4	5.8	1.8	3000	29	98.0		0.05					98.0		200 ml of ML wasted for analyses
	23:00	7.4	5.7			28			0.08							
Jun-22	9:00	6.5	5.9	1.6	3000	29	98.0		0.36					97.7		pH probed cloged, pH ~ 6.5 for several hou
	23:00	7.4	5.8			28			0.18							
Jun-23	9:00	7.3	6.1	1.9	3000	29	130.0		0.05					98.3		
	17:00	7.4	5.9			29			0.08							
	22:30	7.3	5.8			30			0.06							
Jun-24	8:30	7.4	5.9	1.8	3000	30	130.0		0.07					130.0		200 ml of ML wasted for analyses
	17:00	7.3	5.9			30			0.28							
	22:30	7.4	5.8			29			0.36							
Jun-25	9:00	7.4	5.7	1.7	3000	29	130.0		0.18					129.9	0.02129	
	17:00	7.5	5.9			30			0.39							
	22:30	7.3	5.8			30			0.32							
Jun-26	9:00	7.4	6.1	1.8	3000	29	130.0		0.02				6100/8900	130.2	0.02134	Temp adjudted at 28 oC
	17:00	7.4	5.7			28			0.16				R = 0.685			250 ml of ML wasted for analyses
	22:30	7.4	5.9			27			0.12							
Jun-27	9:00	7.5	5.8	1.8	3000	28	130.0		0.05					130.0	0.02131	200 ml of ML wasted
	17:00	7.3	5.9			28			0.08							
	22:30	7.4	5.8			27			0.06							
Jun-28	10:00	7.4	5.7	1.6	3000	27	130.0		0.05					130.0	0.02203	Temp adjusted at 27 o C
	23:00	7.3	5.9			27			0.12							200 ml of ML wasted
Jun-29	8:30	7.4	5.8	1.6	3000	26	130.0		0.06					130.0	0.02203	
	22:30	7.3	6.1			27			0.04							
Jun-30	9:00	7.4	5.7	1.8	3000	26	130.0		0.05				5900/9100	130.0	0.02204	Temp adjusted at 26 oC
	17:00	7.4	5.9			27			0.09				R = 0.648			250 ml of ML wasted for analyses
	22:30	7.5	6.1			26			0.08							
Jul-01	8:30	7.3	6.2	1.9	3000	26	130.0		0.04					130.0	0.02204	200 ml of ML wasted
	22:30	7.4	6.1			26			0.06							
Jul-02	9:00	7.4	6.2	1.8	3000	26	130.0		0.04					130.0	0.02203	200 ml of ML wasted
	17:00	7.5	5.9			26			0.05							Raw feed started
	22:30	7.3	6.1			26			0.06							
Jul-03	9:00	7.4	6.2	1.9	3000	26	130.0		0.04					130.0		
	17:00	7.5	5.9			26			0.08							
	22:30	7.3	6.1			26			0.06							
Jul-04	8:30	7.4	6.2	2.6	3000	26	130.0		0.05					130.0		
	17:00	7.3	6.1			26			0.08							
	23:00	7.4	6.2			26			0.06							
Jul-05	9:00	7.4	5.9	2.2	3000	26	130.0		0.05					130.0	0.02453	Temp adjusted at 25 oC
	22:30	7.5	6.1			25			0.08							250 ml of ML wasted for analyses
Jul-06	8:30	7.3	5.9	2.1	3000	25	130.0		0.06					130.0	0.02453	
	23:00	7.4	6.1			26			0.05							
Jul-07	8:30	7.4	6.2	2.4	3000	25	130.0		0.12				5300/7500	129.9	0.02452	200 ml of ML wasted
	14:00	7.5	5.9			25			0.06				R = 0.706			New batch
	17:30	7.3	6.1			25			0.04							
	22:30	7.4	6.2			25			0.05							
Jul-08	9:00	7.3	5.9	1.9	3000	25	118.0		0.09					130.0	0.02453	200 ml of ML wasted
	17:00	7.4	6.1			25			0.17							
	22:30	7.4	6.2			25			0.12							200 ml of ML wasted

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TABLE 5.18

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION AT 25°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				ML VSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	Comments
		pH (St Un)	DO (mg/L)	DO (15 min	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Jul-09	8:30	7.5	6.1	2 7	3000	25	118.0		0.05					118.0	0.02227	
	17:00	7.3	6.2			25			0.06							
	23:00	7.4	5.9			25			0.08							
Jul-10	8:30	7.4	6.1	2 5	3000	25	118.0		0.17					117.9		250 ml of ML wasted for analyses
	17:00	7.6	5.9			25			0.08							
	22:00	7.7	6.1			25			0.07							
Jul-11	9:00	7.5	6.2	2 2	3000	25	118.0		0.08					118.1		
	17:30	7.4	5.9			24			0.12							
	22:30	7.6	6.1			25			0.06							
Jul-12	9:00	7.5	6.2	2 4	3000	24	118.0		0.04					118.0	0.02409	Temp adjusted at 24oC
	22:00	7.4	6.1			24			0.05							250 ml of ML wasted for analyses
Jul-13	9:00	7.7	6.2	2 2	3000	25	118.0		0.06				4900/6600	118.0	0.02408	5 g PAC added
	22:00	7.3	5.9			24			0.04				R = 0.742			
Jul-14	8:30	7.6	6.1	2 3	3000	24	118.0		0.05					118.0	0.02408	
	17:00	7.4	5.9			24			0.09							
	23:00	7.5	6.1			24			0.09							
Jul-15	9:00	9.6	5.9	1 9	3000	24	118.0		0.3					117.8	0.02403	pH probe mulfunction, soda ash overdose
	17:00	7.5	6.1			24			0.2							pH adjustment with H3PO4
	23:00	7.4	6.2			25			0.16							No change in feed
Jul-16	9:00	7.6	5.9	2 2	3000	25	118.0		0.16					118.1	0.02229	pH adjustment with H3PO4
	17:00	7.5	6.1			25			0.21							5 g PAC added, temp adjusted at 25 oC
	23:00	7.4	6.2			25			0.18							
Jul-17	9:00	7.7	6.1	2 1	3000	26	118.0		0.09				5300/7400	118.1	0.02228	15 g PAC added
	17:00	7.3	6.2			25			0.07				R= 0.716			temp adjusted at 26 oC
	23:00	7.6	5.9			25			0.12							
Jul-18	9:00	7.5	6.1	2 2	3000	26	118.0		0.09					118.0	0.02226	15 g PAC added
	17:00	7.4	5.9			26			0.08							
	23:00	7.6	6.1			25			0.07							
Jul-19	9:00	7.5	6.2	1 9	3000	26	118.0		0.09					118.0		1L ML exchanged with R # 1
	22:00	7.4	5.9			26			0.14							15 g PAC added
Jul-20	8:00	7.4	6.1	2 1	3000	26	118.0		0.02					118.1	0.01789	1L ML exchanged with R # 1
	22:00	7.3	5.9			26			0.09							10 g PAC added
Jul-21	9:00	7.6	6	2 1	3000	25	118.0		0.04				6600/8700	118.0	0.01788	1L ML exchanged with R # 1
	17:00	7.5	6.1			26			0.06				R = 0.758			
	23:00	7.4	6.2			26			0.08							
Jul-22	8:30	7.4	5.9	1 8	3000	26	164.0		0.04					118.0	0.01788	Aerators partly replaced
	17:00	7.4	6.4			26			0.05							Air flow adjusted
	23:00	7.3	6.6			26			0.06							
Jul-23	9:00	7.4	6.8	2 8	3000	26	164.0		0.05					164.0		air flow adjusted
	17:00	7.4	6.5			25			0.07							
	23:00	7.5	6.7			26			0.08							
Jul-24	9:00	7.3	6.8	3 1	3000	25	164.0		0.05					164.0	0.02247	Temp adjusted at 25 oC
	17:00	7.3	6.8			25			0.06							
	23:00	7.6	6.5			25			0.05							
Jul-25	9:00	7.5	7.6	3 8	3000	25	164.0		0.02				7300/9200	164.0	0.02247	Wasting 150 ml of ML
	17:00	7.4	6.8			25			0.08				R = 0.793			
	23:00	7.6	6.5			25			0.06							
Jul-26	9:00	7.3	6.7	2.8	3000	25	164.0		0.06					164.0	0.02246	Wasting 150 ml of ML
	22:00	7.6	6.8			24			0.03							
Jul-27	9:00	7.5	6.5	3.1	3000	24	164.0		0.05					164.0	0.02247	Wasting 150 ml of ML
	22:00	7.4	6.7			25			0.02							

TABLE 5.18

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
STEADY STATE OPERATION AT 25°C AND QUICK FEED TIME
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	Comments
		pH (St Un)	DO (mgO2/L)	DO (15 min	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS				
Jul-28	8:30	7.3	6.8	7.9	3000	24	134.0		0.02					164.0		Wasting 150 ml of ML
	17:00	7.6	7.3			24			0.06							Temp adjusted at 24 oC
	23:00	7.5	6.5			24			0.04							
Jul-29	9:00	7.4	6.7	7.4	3000	24	134.0		0.03					134.0	0.02197	Wasting 200 ml of ML
	17:00	7.4	6.8			24			0.1							
	22:30	7.5	6.5			24			0.12							
Jul-30	9:00	7.3	6.7	7.6	3000	24	134.0		0.09				6100/7800	133.9	0.02196	Wasting 150 ml ML
	17:00	7.3	6.8			24			0.06				R = 0.782			
	22:30	7.6	6.5			23			0.08							

TABLE 5.19

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1
OPTIMIZATION OF TREATMENT AT DIFFERENT CONDITIONS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					Analytical Data					
		pH (St Un)	DO (mgO$_2$/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	Effluent NH_3-N	VSS/TSS Ratio	NH_3-N Removed (mg/L)	NH_3-N/VSS (mg/mg)	Comments
	17:00	7.4	6.8			21		0.02				600 mg FeCl3 added
	22:30	7.3	6.6			22		0.04				Temp. adjusted at 21 oC
Sep-16	9:00	7.4	6.6	3.2	3000	21	164.0	0.02	5900/9200	164.0		1L of ML replaced with water
	17:00	7.3	6.8			21		0.04	R = 0.641			600 mg FeCl3 added
	22:30	7.3	6.6			21		0.02				
Sep-17	9:00	7.6	6.8	2.9	3000	20	164.0	0.02		164.0		1L ML replaced with water
	16:30	7.5	6.7			21		0.04				600 mg FeCl3 added
	22:00	7.7	6.6			21		0.02				
Sep-18	9:00	7.3	6.7	3.1	3000	20	178.0	0.08		163.9	0.04204	
	17:30	7.3	6.6			20		0.05				
	22:30	7.4	6.8			20		0.06				
Sep-19	9:30	7.3		2.9	3000	20	178.0	0.07	3900/5900	178.0	0.04564	600 mg FeCl3 added
	17:30	7.3	6.8			20		0.08	R = 0.661			Wasted 150 ml ML
	22:30	7.4	6.7			20		0.05				
Sep-20	8:30	7.3	6.6	3.3	3000	21	178.0	0.08		178.0	0.04564	Wasted 100 ml ML
	22:30	7.3	6.8			21		0.02				600 mg FeCl3 added
Sep-21	8:30	7.4	6.7	3.1	3000	20	178.0	0.04		178.0	0.04685	600 mg FeCl3 added
	22:30	7.3	6.6			20		0.02				
Sep-22	9:30	7.5	6.8	3.2	3000	21	178.0	0.03	3800/5200	178.0	0.04684	600 mg FeCl3 added
	17:30	7.4	6.7			22		0.04	R = 0.73			Upset induced by turning off air with 2 feed cycles
Details for Sep-22 till Sep-25 in Upset Summary Table 5.19a												
Sep-25	9:30	7.5	6.6	3.3	3000	29	178.0	0.09		178.0		600 mg FeCl3 added
	17:30	7.7	6.7			29		0.06				Wasted 150 ml ML
	22:30	7.3	6.8			27		0.07				
Sep-26	9:30	7.3	6.7	3.1	3000	25	178.0	0.05		178.0		600 mg FeCl3 added
	22:30	7.4	6.7			25		0.06				
Sep-27	9:30	7.5	6.6	3.2	3000	23	178.0	0.05		178.0		600 mg FeCl3 added
	22:30	7.7	6.7			23		0.07				Wasted 150 ml ML
Sep-28	9:30	7.3	6.8	3.1	3000	23	178.0	0.04		178.0	0.04045	600 mg FeCl3 added
	22:30	7.3	6.7			22		0.06				
Sep-29	9:30	7.4	6.7	3.1	3000	23	178.0	0.05	4400/6300	178.0	0.04045	600 mg FeCl3 added
	17:30	7.3	6.6						R = 0.698			Upset induced by NaOH addition to pH 11.5 with one feed cycle

TABLE 5.19

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1
OPTIMIZATION OF TREATMENT AT DIFFERENT CONDITIONS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					Analytical Data					
		pH (St Un)	DO (mgO_2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	Effluent NH_3-N	VSS/TSS Ratio	NH_3-N Removed (mg/L)	NH_3-N/VSS (mg/mg)	Comments
Details for Sep-29 till Oct-3 in Upset Summary Table 5.19b												
Oct-03	9:00	7.6	6.8	2.9	3000	30	178.0	0.03		178.0		600 mg FeCl3 added
	17:00	7.3	6.7			30		0.06				Wasted 150 ml ML
	22:00	7.6	6.6			29		0.04				
Oct-04	9:00	7.5	6.6	3.1	3000	30	178.0	0.03		178.0	0.04045	600 mg FeCl3 added
	22:00	7.6	6.6			30		0.04				Wasted 150 ml ML
Oct-05	9:00	7.5	6.7	2.9	3000	29	178.0	0.05	4200/6400	178.0	0.04045	600 mg FeCl3 added
	22:00	7.3	6.7			30		0.06	R = 0.656			Wasted 100 ml ML
Oct-06	8:30	7.3	6.8	3		30		0.05				600 mg FeCl3 added
	17:00	7.4	6.7		3500	30	207.7	0.03		207	0.04705	**Feed extended to 4 days HRT**
	22:30	7.3	6.7			30		0.03				New timer installed
Oct-07	9:00	7.3	6.6	2.8	3750	30	222.5	0.04		222		600 mg FeCl3 added
	17:00	7.4	6.8			30		0.05				Wasted 100 ml ML
	22:30	7.3	6.6			30		0.03				**Feed extended to 3.5 days HRT**
Oct-08	8:30	7.4	6.8	2.6	4000	30	237.3	0.06		237		600 mg FeCl3 added
	17:00	7.3	6.6			30		0.05				Wasted 200 ml ML
	22:00	7.6	6.8			30		0.03				
Oct-09	8:30	7.5	6.7	2.7	4500	30	267.0	0.04		267	0.06512	600 mg FeCl3 added
	17:00	7.6	6.6			30		0.05				Wasted 200 ml ML
	22:00	7.5	6.6			30		0.03				
Oct-10	8:30	7.8	6.6	2.9	5000	29	296.7	0.03	4100/6300	297	0.07244	**Feed extended to 3 days HRT**
	17:00	7.7	6.8			28		0.04	R = 0.650			Temp set up at 28oC
	22:00	7.8	6.7			28		0.05				600 mg FeCl3 added
Oct-11	9:00	7.9	6.6	2.6	5000	26	296.7	0.03		297	0.07244	Temp set up at 25 oC
	22:00	7.6	6.8			25		0.03				600 mg FeCl3 added
Oct-12	9:00	7.7	6.7	2.8	5000	24	296.7	0.04		297		Temp set up at 23 oC
	22:30	7.8	6.6			23		0.05				600 mg FeCl3 added
Oct-13	9:00	7.8	6.8	2.7	5000	23	296.7	0.03		297	0.08250	600 mg FeCl3 added
	22:00	7.9	6.7			23		0.06				Wasted 200 ml ML
Oct-14	8:30	7.6	6.6	2.8	5000	21	296.7	0.05	3600/5500	297	0.08250	600 mg FeCl3 added
	17:00	7.8	6.6			20		0.04	R = 0.650			**Heater removed**
	22:00	7.5	6.6			20		0.08				Wasted 200 ml ML
Oct-15	8:30	7.8	6.9	3.2	5000	20	296.7	0.03		297	0.10241	600 mg FeCl3 added
	17:00	7.9	7.2			19		0.11				Wasted 250 ml ML
	22:00	7.8	7.5			20		0.09				
Oct-16	9:00	7.9	7.8	3.3	5000	19	296.7	0.04	2900/4600	297	0.10241	600 mg FeCl3 added
	17:00	7.8	7.6			19		0.03	R = 0.63			Wasted 250 ml ML
	22:00	7.9	7.2			19		0.04				
Oct-17	8:30	7.9	7.4	3.5	1800	19	106.8	0.02				**Last feed to the system**
	16:00	7.8	7.1			19		0.06				200 mg FeCl3 added

TABLE 5.19a

SUMMARY OF RESULTS FROM FIRST INDUCED UPSET AND RECOVERY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Time*	*Action*	*Measurements*			*Comments*
			pH (St Units)	*DO (mg/L)*	*NH3-N(mg/L)*	
Sep-22	17:30	Aeration turned off	7.3	6.9	0.08	Mixer still on during feed pH controller on
	18:00	Feed 1000 ml raw				Temp 22.6 oC
Sep-23	2:00	Feed 1000 ml raw				
	8:00	Aeration turned on Temperature adjusted at 30 oC 3 L effluent discharged and replaced with water Sample of effluent collected for Microtox	7.5	0.6	66.5	First washing
	10:00	Aeration and mixing turned off	7.4	6.7	12.2	Rel. good settling
	12:00	3 L of supernatant discharged and replaced with water Aeration and mixing turned on	7.3	0.9	4.2	Second washing
	13:00	Aeration and mixing turned off	6.9	6.6	0.28	
	15:00	3 L of supernatant discharged and replaced with water Aeration and mixing turned on Sample of supernatant collected for Microtox	7.4	0.7	0.14	Third washing
	16:00	Aeration and mixing turned off	7.3	6.5	0.09	
	17:30	3 L of supernatant discharged and replaced with water Aeration and mixing turned on 3L of ML exchanged with Reactor 2 Sample of filtered ML collected for Microtox	7.1	0.9	0.06	First seeding

TABLE 5.19a

SUMMARY OF RESULTS FROM FIRST INDUCED UPSET AND RECOVERY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Time*	*Action*	*Measurements*			*Comments*
			pH (St Units)	*DO (mg/L)*	*NH3-N(mg/L)*	
	18:00	Feed with a mixture 50% raw and 50 % water Aeration and mixing turned on	7.2	6.8	0.05 (after feed:8.5)	First feed with 50% raw
	22:00	Monitoring	7.3	6.7	0.12	
Sep-24	2:00	Feed with a mixture 50% raw and 50 % water				Second feed with 50% raw
	8:30	Effluent collected for analyses	7.2	0.2	0.04	First effluent after upset Good Settling
	10:00	Resume feed with 75% raw and 25% water 2L ML exchanged with Reactor 2 ML sample for Microtox	7.3	6.7	0.03 (after feed:18.6)	First feed with 75% raw
	11:00	Biokinetcs measurements	7.4	4.3	4.6	
	12:00	Biokinetcs measurements	7.2	5.8	0.38	
	18:00	Feed with 100 % raw	7.3	6.6	0.09	First feed with 100% raw
	22:00	Monitoring	7.4	6.8	0.12	

TABLE 5.19a

SUMMARY OF RESULTS FROM FIRST INDUCED UPSET AND RECOVERY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Time*	*Action*	*Measurements*			*Comments*
			pH (St Units)	*DO (mg/L)*	*NH3-N(mg/L)*	
Sep-25	2:00	Feed with 100 % raw				Second feed with 100% raw
	8:30	Monitoring/effluent	7.2	6.6	0.05	First effluent after 2 feed with 100% raw
	10:00	Monitoring Mixed Liquor During Feed Cycle	7.6	6.7	0.06	Start feed cycle with 100% raw
	10:15		7.4	3.2	5.8	
	10:30		7.2	1.8	10.1	
	11:00		7.2	1.7	21.4	End of feed cycle with 100% raw
	11:15		7.1	2.3	14.7	Second day of feed with 100% raw
	11:30		7.2	2.4	10.2	
	12:00		7.1	2.6	1.2	
	12:30		7.1	5.9	0.09	
	15:00	Temperature set up at 27 oC				
	17:00	Monitoring Mixed Liquor During Feed Cycle	7.7	6.6	0.04	Start feed cycle with 100% raw
	17:15		7.2	2.9	6.2	Temperature:26.8 oC
	17:30		7.1	1.9	10.9	
	17:45		7.2	2.1	16.3	
	18:00		7.1	2.1	20.2	End of feed cycle with 100% raw
	18:15		7.1	2.2	14.5	
	18:30		7.1	2.5	10.8	
	18:45		7.1	2.6	4.4	
	19:00		7.1	2.7	1.1	
	19:15		7.1	4.4	0.32	Biokinetics close to that before upset

SUMMARY OF RESULTS FROM SECOND INDUCED UPSET AND RECOVERY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Time*	*Action*	*Measurements*			*Comments*
			pH (St Units)	*DO (mg/L)*	*NH3-N(mg/L)*	
Sep-29						
	19:00	NaOH solution added to raise pH to ~ 11.5	7.3	6.9	0.08	Mixing and aeration ON Temp 22.9 oC
	22:30	Monitoring	10.8	7.2	46.3	Substantial foaming,
Sep-30						
	8:30	Effluent collected for analyses and Microtox Temperature adjusted at 30 oC pH adjusted with phosphoric acid to 7.5	9.6	6.8	42.6	
		3 L effluent discharged and replaced with water				First washing
	9:30	Aeration and mixing turned off	7.4	6.6	16.8	Bad settling, ferric and anionic polymer added
	12:00	3 L of supernatant discharged and replaced with water Aeration and mixing turned on	7.5	3.8	12.5	Second washing
	13:00	Aeration and mixing turned off	7.4	6.6	8.3	Still bad settling,ferric and anionic polymer added
	15:00	3 L of supernatant discharged and replaced with water Aeration and mixing turned on Sample of supernatant collected for Microtox	7.4	3.2		Third washing
	16:00	Aeration and mixing turned off	7.5	6.5	4.2	Better settling, no polymer required
	19:00	3 L of supernatant discharged and replaced with water Aeration and mixing turned on 3 L of ML exchanged with Reactor 2 Sample of filtered ML collected for Microtox	7.5	2.9	3.8	First seeding
	22:00	Monitoring	7.5	6.7	3.5	

SUMMARY OF RESULTS FROM SECOND INDUCED UPSET AND RECOVERY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Time*	*Action*	*Measurements*			*Comments*
			pH (St Units)	*DO (mg/L)*	*NH3-N(mg/L)*	
Oct-01						
	2:00	Feed with a mixture: 50% raw and 50 % water				First feed with 50% raw
	8:30	Monitoring	7.3	6.7	0.85	Good settling but effluent very turbid
		3L of ML exchanged with Reactor 2				
		Sample of filtered ML collected for Microtox				Second seeding
	9:00	Feed with a mixture: 75% raw and 25 % water				First feed with 75% raw
						Biokinetics very slow ~ 0.1 mgNH3-N/min
	10:00	Monitoring after feed	7.2	6.5	16.6	
	11:00		7.3	3.8	8.2	
	12:00		7.3	4.2	3.8	
	13:00		7.2	5.3	1.1	
	16:00	3L of ML exchanged with Reactor 2	7.6	6.8	0.32	Third seeding
		Feed with a mixture: 75% raw and 25 % water				Second feed with 75% raw
	18:00	Monitoring after feed	7.5	2.6	24.4	Better biokinetics: 0.37 mgNH3-N/min
	18:15		7.2	3.8	18.8	
	18:30		7.1	3.7	14.2	
	18:45		7	3.7	10.1	
	19:00		6.9	3.7	5.9	
	19:30		7.1	3.8	1.2	
	22:00	Monitoring	7.7	6.5	0.06	

TABLE 5.19b

SUMMARY OF RESULTS FROM SECOND INDUCED UPSET AND RECOVERY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Time*	*Action*	*Measurements*			*Comments*
			pH (St Units)	*DO (mg/L)*	*NH3-N(mg/L)*	
Oct-02						
	2:00	Feed with a mixture: 75% raw and 25 % water				Third feed with 75% raw
	8:30	Monitoring	7.8	6.8	0.05	Good settling, effluent still turbid
		3L of ML exchanged with Reactor 2				Fourth seeding
	9:00	Feed with 100% raw				First feed with 100% raw
	10:00	Monitoring after feed	7.2	2.2	36.5	Biokinetics slower as for 75% raw
	10:15		7.3	2.2	32.8	
	10:30		7	2.3	28.4	
	11:00		7.1	2.3	22.1	
	11:30		7.1	2.3	17.6	
	12:00		7.1	2.5	6.8	
	13:00		7.1	5.6	0.22	
	16:00	1L of ML exchanged with Reactor 2	7.8	6.8	0.06	Fifth seeding
	17:00	Feed with 100% raw	7.7	6.7	0.05	Second feed with 100% raw
	22:30	Monitoring	7.7	6.8	0.06	
Oct-03						
	2:00	Feed with 100% raw				Third feed with 100% raw
	8:30	Monitoring	7.8	6.7	0.04	
	9:00	Feed with 100% raw				
	10:00	Monitoring after feed	7.4	1.9	32.8	Biokinetics recovered to that before upset
	10:15		7.2	2.1	25.1	
	10:30		7.1	2.1	18.3	
	11:00		7.1	2.3	6.2	
	11:30		7.1	4.5	0.39	
	12:00		7.1	5.6	0.12	
	13:00		7.1	6.3	0.05	

TABLE 5.20

SUMMARY OF ANALYTICAL DATA FOR SBR1
BEFORE AND AFTER FIRST INDUCED UPSET
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Parameter (*mg/L*)	*Sample*		
	Raw Mixture	*Effluent Before Upset*	*Effluent After Upset*
pH (st Units)	7.6	6.9	7.3
Ammonia as N	440	<0.05	59
TKN	890	<0.2	170
Nitrate as N	0.5	460	430
COD	1400	120	150
TOC	360	44	46
DOC	320	17	20
Phenols	140	0.014	0.014
Thiocyanate	160	2.8	10
Total Cyanide	2.1	0.14	0.15
TSS	42	32	64
Arsenic	8.3	0.81	1.4
Sulfate	190	870	840

TABLE 5.21

SUMMARY OF ANALYTICAL DATA FOR SBR1
BEFORE AND AFTER SECOND INDUCED UPSET
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Parameter	*Sample*		
(mg/L)	*Raw Mixture*	*Effluent Before Upset*	*Effluent After Upset*
pH (st Units)	7.4	7	9.6
Ammonia as N	500	0.5	42
TKN	720	1.2	60
Nitrate as N	0.5	440	350
COD	1300	170	380
TOC	350	32	110
DOC	270	12	20
Phenols	162	0.013	0.019
Thiocyanate	160	3.2	21
Total Cyanide	2.7	0.07	0.35
TSS	14	38	107
Arsenic	6.3	0.74	1.5
Sulfate	180	890	770

TABLE 5.22

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
OPTIMIZATION OF TREATMENT AT DIFFERENT CONDITIONS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					Analytical Data					
		pH (S. Un)	D.O (mgO2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	NH_3-N Effluent (mg/L)	MLVSS/MLTSS Ratio	NH_3-N Removed (mg/L)	NH_3-N/VSS (mg/L)	Comments
Aug-18	8:30	7.6	7.9	5.4	3000	21	142.0	0.04	7300/9400	142.0	0.01821	Cooling adjusted
	17:00	7.6	7.8			20		0.14				Wasted 175 ml ML
	22:00	7.7	7.9			21		0.22				
Aug-20	9:00	7.5	8.2	5.8	3000	20	142.0	0.06		142.1	0.01822	Wasted 150 ml ML
	17:00	7.4	7.9			20.5		0.09				
	22:00	7.5	8.1			20.5		0.12				
Aug-21	8:30	7.6	7.9	5.3	3000	20	142.0	0.06		142.0	0.01973	Cooling adjusted
	17:00	7.5	8.1			20		0.09				Wasted 175 ml ML
	22:00	7.4	7.9			20		0.07				
Aug-22	8:30	7.4	7.8	5.2	3000	20	142.0	0.02	7200/9250	142.1	0.01973	Wasted 100 ml ML
	17:00	7.5				20		0.06	R = 0.778			
	22:30	7.4	7.9			20		0.08				
Aug-23	9:00	7.4	7.8	4.9	3000	20	142.0	0.02		142.0	0.01973	Wasted 100 ml ML
	22:00	7.5	7.9			20		0.05				
Aug-24	8:30	7.3	8.1	5.3	3000	19.5	200.0	0.03		142.0		Cooling adjusted
	22:00	7.3	7.9			20		0.04				
Aug-25	9:00	7.6	8.1	5.2	3000	19.5	200.0	0.05		200.0		Cooling adjusted
	17:00	7.5	7.9			19		0.06				Wasted 200 ml ML
	22:30	7.6	8.2			19		0.11				
Aug-26	8:30	7.7	7.8	4.9	3000	19	200.0	0.04		200.0		Wasted 100 ml ML
	17:00	7.6	8.1			19.5		0.12				
	22:00	7.5	7.9			19		0.22				
Aug-27	9:30	7.6	7.9	4.8	3000	19	200.0	0.09		200.0	0.02816	700 ml ML taken for respirometry
	17:00	7.6	8.1			19.5		0.18				10 g PAC added
	22:30	7.5	7.9			19		0.22				
Aug-28	8:30	7.6	7.8	4.6	3000	19	200.0	0.9	7100/9300	199.2	0.02805	
	17:00	7.6	8.1			19		0.24	R = 0.763			
	22:00	7.5	8.1			19		0.26				
Aug-29	9:00	7.6	7.9	4.7	3000	19	144.0	0.12		200.8	0.02828	Cooling shut down
	17:00	7.7	7.8			22		0.06				
	22:00	7.6	8.1			23		0.08				
Aug-30	9:00	7.6	7.9	4.5	3000	28	144.0	0.04		144.1		Heating installed
	22:00	7.5	8.1			29		0.03				
Aug-31	9:00	7.6	7.9	4.8	3000	29	144.0	0.02		144.0	0.02150	
	21:30	7.7	7.8			28		0.04				
Sep-01	9:00	7.6	8.1	4.6	3000	29	144.0	0.03	6700/8300	144.0	0.02149	2.5 L ML replaced with water
	22:00	7.5	7.9			29		0.02	R = 0.81			
Sep-02	8:30	7.6	7.8	4.5	3000	30	144.0	0.03		144.0	0.02149	1.0 L ML replaced with water
	7:00	7.2	7.2			30		0.08				
	12:00	7.6	6.9			29		0.06				

TABLE 5.22

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
OPTIMIZATION OF TREATMENT AT DIFFERENT CONDITIONS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					TKN load (mg/L)	Analytical Data				
		pH (St Un)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp		NH_3-N Effluent (mg/L)	MLVSS/MLTSS Ratio	NH_3-N Removed (mg/L)	NH_3-N/VSS (mg/L)	Comments
Sep-03	8:30	7.6	6.8	3.8	3000	30	160.0	0.03		144.0		1.0 L ML replaced with water
	17:00	7.5	6.7			29		0.07				
	22:00	7.6	6.9			30		0.04				
Sep-04	9:00	7.7	6.6	3.2	3000	30	160.0	0.03		160.0	0.03333	1.0 L ML replaced with water
	16:30	7.6	6.8			29		0.04				
	22:00	7.6	6.7			30		0.03				
Sep-05	8:30	7.5	6.8	3.1	3000	30	160.0	0.04	4800/6200	160.0	0.03333	Wasted 175 ml ML
	17:00	7.6	6.7			29		0.03	R = 0.77			
	22:00	7.6	6.9			30		0.02				
Sep-06	9:00	7.6	6.8	3.3	3000	31	160.0	0.04		160.0	0.03333	450 mg FeCl3 added
	22:00	7.5	6.8			30		0.04				
Sep-07	9:00	7.6	6.7	3.2	3000	30	160.0	0.03		160.0		450 mg FeCl3 added
	22:00	7.7	6.9			29		0.02				
Sep-08	8:30	7.6	6.6	3.2	3000	30	160.0	0.04		160.0	0.03265	600 mg FeCl3 added
	17:00	7.5	6.6			29		0.04				
	22:30	7.4	6.8			29		0.03				
Sep-09	8:30	7.4	6.7	3.3	3000	30	160.0	0.02	4900/6600	160.0	0.03266	600 mg FeCl3 added
	17:00	7.5	6.8			30		0.04	R = 0.742			Wasted 175 ml ML
	22:30	7.3	6.6			29		0.04				
Sep-10	9:00	7.3	6.8	3.4	3000	29	160.0	0.03		160.0	0.03265	600 mg FeCl3 added
	16:30	7.6	6.7			29		0.02				Wasted 150 ml ML
	22:00	7.5	6.8			30		0.04				
Sep-11	9:00	7.3	6.6	3.2	3000	30	160.0	0.03		160.0	0.03137	900 mg FeCl3 added
	16:30	7.4	6.6			29		0.04				Wasted 150 ml ML
	22:00	7.4	6.8			29		0.03				
Sep-12	9:00	7.4	6.7	3.3	3000	30	160.0	0.04	5100/7000	160.0	0.03137	900 mg FeCl3 added
	17:00	7.4	6.8			30		0.03	R = 0.728			Wasted 150 ml ML
	22:30	7.4	6.6			29		0.04				
Sep-13	9:00	7.5	6.8	3.2	3000	30	160.0	0.03		160.0	0.03137	Temp adjusted at 27 oC
	22:00	7.3	6.7			28		0.02				900 mg FeCl3 added
Sep-14	8:00	7.3	6.8	3.2	3000	27	160.0	0.04		160.0		
	22:00	7.4	6.7			28		0.04				
Sep-15	8:30	7.3	6.6	3.1	3000	27	160.0	0.03		160.0		900 mg FeCl3 added
	17:00	7.3	6.6			27		0.03				Wasted 100 ml ML
	22:30	7.4	6.6			27		0.02				
Sep-16	9:00	7.4	6.8	3.3	3000	26	160.0	0.04		160.0		Temp. adjusted at 25 oC
	17:00	7.4	6.7			25		0.04				900 mg FeCl3 added
	22:30	7.4	6.8			25		0.03				

TABLE 5.22

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
OPTIMIZATION OF TREATMENT AT DIFFERENT CONDITIONS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					Analytical Data					
		pH (St Un)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	NH_3-N Effluent (mg/L)	MLVSS/MLTSS Ratio	NH_3-N Removed (mg/L)	NH_3-N/VSS (mg/L)	Comments
Sep-17	9:00	7.4	6.6	3.1	3000	25	160.0	0.02		160.0		500 ml ML replaced with water
	16:30	7.5	6.8			24		0.04				900 mg FeCl3 added
	22:00	7.3	6.7			25		0.04				
Sep-18	9:00	7.3	6.8	3.1	3000	24	178.0	0.03		160.0	0.03019	Temp. adjusted at 23 oC
	17:00	7.4	6.9			23		0.04				Wasted 100 ml ML
	22:30	7.4	6.6			24		0.03				
Sep-19	9:00	7.5	6.6	2.9	3000	23	178.0	0.04	5300/7600	178.0	0.03358	600 mg FeCl3 added
	17:00	7.3	6.8			23		0.03	R = 0. 697			Wasted 100 ml ML
	22:00	7.4	6.7			23		0.02				
Sep-20	8:30	7.4	6.8	3.2	3000	22	178.0	0.04		178.0	0.03358	600 mg FeCl3 added
	22:00	7.5	6.6			23		0.04				Wasted 150 ml ML
Sep-21	8:30	7.3	6.8	3.1	3000	23	178.0	0.03		178.0		600 mg FeCl3 added
	22:00	7.3	6.7			22		0.03				
Sep-22	9:00	7.4	6.8	3.2	3000	22	178.0	0.02		178.0	0.03123	600 mg FeCl3 added
	17:00	7.5	6.6			23		0.04				Wasted 150 ml ML
	22:00	7.4	6.6			23		0.04				
Sep-23	8:30	7.5	6.8	3.3	3000	23	178.0	0.03	5700/7500	178.0	0.03123	600 mg FeCl3 added
	17:00	7.3	6.7			22		0.02	R = 0.76			**3000 ml ML exchanged with R1**
	22:30	7.3	6.8			22		0.04				Wasted 100 ml ML
Sep-24	9:00	7.4	6.9	3.2	3000	23	178.0	0.04		178.0	0.03123	600 mg FeCl3 added
	17:00	7.4	6.8			23		0.05				**2000 ml ML exchanged with R1**
	22:30	7.5	6.7			22		0.03				
Sep-25	8:30	7.3	6.7	3.1	3000	22	178.0	0.04		178.0		600 mg FeCl3 added
	17:00	7.4	6.6			23		0.03				Wasted 100 ml ML
	22:30	7.4	6.6			23		0.04				
Sep-26	9:00	7.5	6.6	3.2	3000	23	178.0	0.03		178.0		600 mg FeCl3 added
	22:00	7.3	6.8			22		0.04				Wasted 100 ml ML
Sep-27	9:00	7.4	6.7	3.1	3000	22	178.0	0.03		178.0		600 mg FeCl3 added
	22:00	7.3	6.8			23		0.04				
Sep-28	9:00	7.4	6.7	3.1	3000	23	178.0	0.03		178.0	0.03633	600 mg FeCl3 added
	22:00	7.5	6.6			22		0.02				Wasted 150 ml ML
Sep-29	9:00	7.4	6.6	2.9	3000	23	178.0	0.04	4900/6600	178.0	0.03632	600 mg FeCl3 added
	17:00	7.3	6.6			23		0.04	R = 0.742			Wasted 150 ml ML
	22:00	7.4	6.7			23		0.03				
Sep-30	8:30	7.5	6.6	3.1	3000	22	178.0	0.03		178.0	0.03633	600 mg FeCl3 added
	17:00	7.4	6.7			22		0.02				Wasted 150 ml ML
	22:00	7.5	6.6			23		0.05				**3000 ml ML exchanged with R1**
Oct-01	9:00	7.3	6.8	3.3	3000	23	178.0	0.06		178.0		600 mg FeCl3 added
	17:00	7.6	6.8			23		0.04				**3000 ml ML exchanged with R1**
	22:30	7.8	6.9			23		0.03				

TABLE 5.22

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2
OPTIMIZATION OF TREATMENT AT DIFFERENT CONDITIONS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	Time	Operational Parameters					Analytical Data					
		pH (St Un)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	NH_3-N Effluent (mg/L)	MLVSS/MLTSS Ratio	NH_3-N Removed (mg/L)	NH_3-N/VSS (mg/L)	Comments
Oct-02	9:00	7.7	6.8	3.2	3000	22	178.0	0.02		178.0		**3000 ml ML exchanged with R1**
	17:00	7.6	6.7			22		0.04				Wasted 150 ml ML
	22:30	7.8	6.7			23		0.04				600 mg FeCl3 added
Oct-03	9:00	7.5	6.8	3.1	3000	23	178.0	0.03		178.0		**1000 ml ML exchanged with R1**
	17:00	7.6	6.9			22		0.03				Wasted 150 ml ML
	22:30	7.8	6.8			22		0.02				600 mg FeCl3 added
Oct-04	8:30	7.7	6.7	2.9	3000	23	178.0	0.04		178.0	0.03869	Wasted 150 ml ML
	22:30	7.6	6.7			23		0.04				600 mg FeCl3 added
Oct-05	9:00	7.8	6.6	2.8	3000	23	178.0	0.03	4600/6500	178.0	0.03870	Wasted 150 ml ML
	22:00	7.6	6.6			22		0.02	R = 0.707			600 mg FeCl3 added
Oct-06	8:30	7.8	6.6	2.9	3000	22	178.0	0.04		178.0	0.03869	Wasted 150 ml ML
	17:00	7.6	6.8			23		0.04				600 mg FeCl3 added
	22:30	7.8	6.7			23		0.03				
Oct-07	8:30	7.7	6.8	3.1	3000	22	178.0	0.04		178.0		Wasted 200 ml ML
	17:00	7.6	6.7			23		0.03				600 mg FeCl3 added
												Feed changed 1 hr with mixing only
	22:30	7.8	6.6			23		0.04				
Oct-08	9:00	7.7	6.8	2.9	3000	23	178.0	0.07		178.0		Wasted 100 ml ML
	17:00	7.6	6.6			22		0.03				600 mg FeCl3 added
	22:00	7.7	6.8			22		0.02				
Oct-09	8:30	7.6	6.9	2.8	3000	22	178.0	0.04		178	0.03956	600 mg FeCl3 added
	17:00	7.8	6.8			23		0.04				Wasted 150 ml ML
	22:00	7.6	6.7			23		0.03				
Oct-10	8:30	7.8	6.7	2.6	3000	23	178.0	0.02	4500/6600	178	0.03956	600 mg FeCl3 added
	17:00	7.6	6.8			22		0.04	R = 0.681			Wasted 150 ml ML
	22:00	7.8	6.8			22		0.03				**Heater removed**
Oct-11	9:00	7.7	6.9	2.5	3000	21	178.0	0.02		178	0.03956	600 mg FeCl3 added
	22:00	7.7	6.8			20		0.04				Wasted 150 ml ML
Oct-12	9:00	7.6	6.7	2.8	3000	20	178.0	0.04		178		600 mg FeCl3 added
	22:30	7.8	6.7			20		0.03				
Oct-13	9:00	7.6	6.8	2.6	3000	20	178.0	0.02		178	0.04564	Wasted 200 ml ML
	22:00	7.8	6.9			20		0.04				600 mg FeCl3 added
Oct-14	8:30	7.6	6.8	2.6	4000	19	237.3	0.04	3900/6100	237	0.06077	**4 days HRT with 75 min feed without air**
	17:00	7.8	6.7			19		0.05	R = 0.64			Wasted 200 ml ML
	22:00	7.7	6.9			19		0.11				600 mg FeCl3 added
Oct-15	8:30	7.9	6.9	2.8	4000	20	237.3	0.03		237	0.07645	Wasted 250 ml ML
	17:00	7.8	6.8			19		0.09				600 mg FeCl3 added
	22:00	7.8	7.1			19		0.12				
Oct-16	9:00	7.9	7.2	3.1	4000	19	237.3	0.04	3100/5200	237	0.07645	Wasted 250 ml ML
	17:00	7.8	7.4			19		0.03	R = 0.6			600 mg FeCl3 added
	22:00	8.1	7.6			19		0.06				
Oct-17	8:30	8.1	7.5	3.4	1400	19	83.1	0.02				**Last feed to the system**
	16:00	7.8	7.8			19		0.04				200 mg FeCl3 added

TABLE 5.23

ANALYSIS OF GROUNDWATER (BATCH 27) AND EFFLUENT FROM SBR2
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Parameter (mg/L)	*Raw MIXTURE 2003-10-07*	*SBR2 Effluent 2003-10-13*	
		Concentration	*Removal (%)*
pH (Std)	7.8	7.2	_
Ammonia as NH3-N	560	0.09	99.98
TKN	690	0.2	99.97
Nitrate as NO3-N	0.5	350	_
COD	1100	110	90.00
Total Organic Carbon	230	25	89.13
DOC	200	17	91.50
Phenol	132		100.00
Thiocyanate	140	1.6	99.99
Total Cyanide	3.4	0.08	97.65
Total Suspended Solids	35	24	_
Volatile Suspended Solids	28	19	_
Arsenic	10	0.48	95.20
Sulfate	210	920	_

TABLE 5.24

RESULTS OF SETTLING TESTS FOR THE REACTOR SBR-2, ON May-21
WAUKEGAN NITRIFICATION STUDY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date: May 21,2003

Run 1: 100% ML, 2L Volume			Run 2: RUN 1, revised with 500 ml exchanged for 500 ml Eff			Run 3: RUN 2, revised with 750 ml exchanged for 750 ml Eff			Run 4: RUN 3, revised with 750 ml exchanged for 750 ml Eff			Run 5: RUN 4, revised with 750 m exchange for 750 ml Eff		
TSS = 9900 mg/L			TSS = 4,900 mg/L			TSS = 1,300 mg/L			TSS = 350 mg/L			TSS = 105 mg/L		
	Volume Settled (Clear)	Settled (Clear) Height		Volume Settled (Clear)	Settled (Clear) Height		Volume Settled (Clear)	Settled (Clear) Height		Volume Settled (Clear)	Settled (Clear) Height		Volume Settled (Clear)	Settled (Clear) Height
(min)	mL	mm	(min)	mL	mm	(min)	mL	mm	(min)	mL	mm	(min)	mL	mm
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	510	77	5	650	99	5	800	122	5	890	136	5	910	138
10	620	94	10	700	106	10	840	128	10	920	140	10	940	143
15	660	100	15	740	113	15	850	130	15	940	143	15	950	145
20	670	102	20	770	117	20	855	131	20	950	145	20	960	147
25	680	104	25	780	119	25	860	132	25	955	146	25	965	148
30	690	105	30	785	120	30	860	133	30	960	147	30	970	149

TABLE 5.25

SETTLING TEST FOR THE REACTOR SBR-1
ON AUGUST 14
WAUKEGAN NITRIFICATION STUDY
WAUKEGAN MANAFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Run 1: 100% ML		
TSS = 8200 mg/L		
(min)	*ft*	*cc/L*
0	0	1000
5	0.17	750
10	0.26	490
15	0.28	450
30	0.31	390
45	0.33	340
60	0.34	295
75	0.35	250
100	0.36	210

TABLE 5.26

MEASUREMENTS OF SLUDGE AND CLEAR LIQUOR AFTER SETTLING
WAUKEGAN NITRIFICATION STUDY
WAUKEGAN MANAFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Reactor 1*				*Reactor 2*			
	Top level (cm)	*Clear Liquor (cm)*	*Sludge (cm)*	*Comment*	*Top level (cm)*	*Clear Liquor (cm)*	*Sludge (cm)*	*Comment*
Aug-29	30	21	9	<-20 mg/L FeCl3	29	19	10	
Aug-30	29	21	8	<-20 mg/L FeCl3	29	20	9	
Aug-31	29	22	7	<-30 mg/LFeCl3	29	19	10	
Sep-01	30	22	8	<-30 mg/LFeCl3	30	20	10	2.5 L ML replaced with water
Sep-02	29	21	8	<-30 mg/LFeCl3	29	22	7	1 L ML replaced with water
Sep-03	29	22	7	<-30 mg/LFeCl3	29	24	5	1 L ML replaced with water
Sep-04	29	22	7	<-40 mg/L FeCl3	30	25	5	1 L ML replaced with water
Sep-10	30	22	8	<-80 mg/L FeCl3	30	25	5	<-50 mg/LFeCl3
Sep-12	30	23	7	<-80 mg/L FeCl3	30	23	7	<-70 mg/LFeCl3
Sep-13	30	24	6	<-40 mg/L FeCl3	30	22	8	<-40 mg/L FeCl3
Sep-27	29	20	10	<-40 mg/L FeCl3	30	22	8	<-40 mg/L FeCl3
Oct-05	30	21	9	<-40 mg/L FeCl3	30	23	7	<-40 mg/L FeCl3
Oct-06	30	22	8	<-40 mg/L FeCl3	30	23	7	<-40 mg/L FeCl3
Oct-10	30	22	8	<-40 mg/L FeCl3	30	23	7	<-40 mg/L FeCl3
Oct-15	30	23	7	<-40 mg/L FeCl3	30	23	7	<-40 mg/L FeCl3

TABLE 5.27

CONCENTRATION OF ARSENIC IN THE INFLUENT, EFFLUENT AND SLUDGES DURING BIOLOGICAL TREATMENT WITHOUT FERRIC CHLORIDE ADDITION
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Arsenic concentration (mg/L)*							
	Reactor SBR-1				*Reactor SBR-2*			
	Influent	*Effluent*	*Removal (%)*	*Sludge (ug/g)*	*Influent*	*Effluent*	*Removal (%)*	*Sludge (ug/g)*
2-Jun	6.4	1.4	78.13	180	1.2	0.48	60.00	61
5-Jun	6.4	1.3	79.69	320	1.2	0.52	56.67	168
9-Jun	6.4	2.2	65.63	830	1.2	0.68	43.33	230
13-Jun	6.8	4.5	33.82	960	1.7	0.62	63.53	290
20-Jun	6.8	6.2	8.82	1190	1.7	0.89	47.65	590
23-Jun	9.2	6.7	27.17	790	1.5	0.98	34.67	822
27-Jun	9.2	6.8	26.09	630	1.5	2.1	-40.00	890
2-Jul	9.2	5.8	36.96	560	1.1	2.2	-100.00	810
6-Jul	7.2	6.6	8.33	840	7.2	3.2	55.56	860
11-Jul	7.2	3.4	52.78	960	7.2	4.2	41.67	990
17-Jul	7.2	5.1	29.17	1300	7.2	5.6	22.22	1100

TABLE 5.28

CONCENTRATION OF ARSENIC IN SLUDGES AND ABSORBING SOLUTION
TESTS ON ARSENIC VOLATILIZATION FROM BIOMASS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Air flow (ml/min)	*Arsenic in sludges (ug/g)*		*Arsenic Removed from Sludge (mg/sample)*	*Arsenic in solution (mg/L)*		*Arsenic Accumulation in Absorbing Solution (mg/sample)*
	Raw sludge	*Aerated sludge*		*After aeration*	*Stock*	
50	830	764	0.693	0.028	0.005	0.046
100	870	756	1.197	0.056	0.005	0.102
200	890	708	1.911	0.036	0.005	0.062

Notes:

Absorbing solution:
0.1% $FeSO_4$ + 0.5 % H_2O_2, pH = 3.5

TABLE 5.29

ARSENIC REMOVAL DURING BIOLOGICAL TREATMENT WITH THE ADDITION OF FERRIC CHLORIDE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Results*							
	SBR 1				*SBR 2*			
	Sludge (ug/g)	*Effluent (mg/L)*	*Sludge/Effluent Ratio*	*Comments*	*Sludge (ug/g*	*Effluent (mg/L)*	*Sludge/Effluent Ratio*	*Comments*
11-Aug	920	6.3	146.03		1100	6.7	164.18	
13-Aug	900	3.8	236.84	10 mg/L FeCl3	1020	6	170.00	
22-Aug	960	5.3	181.13	10 mg/L FeCl3	990	6.5	152.31	
25-Aug	1100	3.1	354.84	20 mg/L FeCl3	980	5.8	168.97	
27-Aug					1080	5.2	207.69	
29-Aug	1310	2.7	485.19	30 mg/L FeCl3	940	6.4	146.88	
1-Sep	1330	2.6	511.54	30 mg/L FeCl3	780	3.8	205.26	Diluted sludge
4-Sep	1360	2.3	591.30	40 mg/L FeCl3	860	3.3	260.61	Diluted sludge
8-Sep	1390	2.1	661.90	60 mg/L FeCl3	890	3.3	269.70	30 mg/L FeCl3
10-Sep	1531	2.1	729.05	80 mg/L FeCl3	1180	2.6	453.85	50 mg/L FeCl3
12-Sep	1680	1.9	884.21	80 mg/L FeCl3	1310	2.1	623.81	70 mg/L FeCl3
15-Sep	1560	1.6	975.00	40 mg/L FeCl3 2 L ML replaced	1420	2	710.00	40 mg/L FeCl3
17-Sep	1370	1.1	1245.45	40 mg/L FeCl3 1 L ML replaced	1490	1.9	784.21	40 mg/L FeCl3 2L ML replaced

TABLE 5.29

ARSENIC REMOVAL DURING BIOLOGICAL TREATMENT WITH THE ADDITION OF FERRIC CHLORIDE
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Results*							
	SBR 1				*SBR 2*			
	Sludge (ug/g)	*Effluent (mg/L)*	*Sludge/Effluent Ratio*	*Comments*	*Sludge (ug/g*	*Effluent (mg/L)*	*Sludge/Effluent Ratio*	*Comments*
19-Sep	1410	1.6	881.25	40 mg/L FeCl3	1310	1.9	689.47	40 mg/L FeCl3
22-Sep	1340	0.81	1654.32	40 mg/L FeCl3	1390	0.98	1418.37	40 mg/L FeCl3
29-Sep	1420	0.74	1918.92	40 mg/L FeCl3	1480	0.72	2055.56	40 mg/L FeCl3
6-Oct	1560	0.71	2197.18	40 mg/L FeCl3	1520	0.7	2171.43	40 mg/L FeCl3
8-Oct	1610	0.68	2367.65	40 mg/L FeCl3	1590	0.62	2564.52	40 mg/L FeCl3
10-Oct	1790	0.72	2486.11	40 mg/L FeCl3	1760	0.53	3320.75	40 mg/L FeCl3
14-Oct	1860	0.39	4769.23	40 mg/L FeCl3	1890	0.55	3436.36	40 mg/L FeCl3
17-Oct	1940	0.63	3079.37	40 mg/L FeCl3	1920	0.64	3000.00	40 mg/L FeCl3

TABLE 5.30

RESULTS OF TCLP TESTING ON SOLIDS GENERATED DURING TREATABILITY STUDY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Parameter (mg/L)	*Sample*			*EPA Regulation*
	Solids from pre-treatment	*Biological sludge*	*Filter cake*	
Arsenic	14	6.8	5.9	5
Barium	0.29	1.9	1.2	100
Cadmium	0.0008	0.008	0.006	1
Chromium	0.005	0.022	0.018	5
Lead	0.005	0.005	0.005	5
Mercury	<0.0001	<0.0001	<0.0001	0.2
Selenium	0.07	0.34	0.36	1
Silver	<0.0001	0.005	0.006	5

TABLE 5.31

ARSENIC REMOVAL FROM BIOLOGICAL EFFLEUNT WITH IRON SALTS
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Effluent Arsenic Conc. (mg/l)	*Treatment* $FeCl_3$ *dose (mg/L)*									
	20		*40*		*60*		*80*		*100*	
	As conc. (mg/L)	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*
5.3	4.2	21	3.8	28	3.6	32	2.3	56	2.2	58
2.6	2.2	15	2.1	19	2.1	19	2.2	15	2.1	19

	$FeSO_4$ dose (mg/L)									
	20		40		60		80		100	
	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)
5.3	4.1	22	3.9	26	3.8	28	3.1	41	2.6	51
2.6	2.3	11	2.2	15	2.2	15	2.1	19	2	23

	1000 mg/L Humates + $FeSO_4$									
	20		40		60		80		100	
	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)
5.3	3.2	39	2.6	51	2.2	58	2.2	58	2.1	60
2.6	2.2	15	2.2	15	2.1	19	2.1	19	2	23

TABLE 5.32

ARESENIC REMOVAL FROM BIOLOGICAL EFFLUENT WITH FENTON'S REAGENT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Effluent Arsenic Conc. (mg/l)

1.Treatment with Humates (1000 mg/L) at pH = 7.4

$FeSO_4$ = 40 mg/L

	H_2O_2 dose (mg/L)							
	50		*100*		*150*		*200*	
	As conc. (mg/L)	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*
5.3	3.1	41	2.3	56	2.1	60	1.8	66
2.6	2.2	15	2	23	1.8	30	1.8	30

$FeSO_4$ = 60 mg/L

	H_2O_2 dose (mg/L)							
	50		*100*		*150*		*200*	
	As conc. (mg/L)	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*	*As conc. (mg/L)*	*Removal (%)*
5.3	2.9	45	2.1	60	1.8	66	1.6	70
2.6	2	23	1.8	30	1.6	38	1.6	38

TABLE 5.32

ARESENIC REMOVAL FROM BIOLOGICAL EFFLUENT WITH FENTON'S REAGENT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

2. Treatment without Humates at pH = 3.5

$FeSO_4$ = 40 mg/L

	H_2O_2 dose (mg/L)							
	50		100		150		200	
	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)
5.3	2.3	56	1.6	70	1.1	79	0.8	85
2.6	1.5	42	1.4	46	0.9	65	0.7	73

$FeSO_4$ = 60 mg/L

	H_2O_2 dose (mg/L)							
	50		100		150		200	
	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)	As conc. (mg/L)	Removal (%)
5.3	2.2	58	1.5	72	0.6	87	0.4	92
2.6	1.4	46	0.8	69	0.4	85	0.3	88

TABLE 5.33

ARSENIC REMOVAL FROM BIOLOGICAL EFFLUENT WITH ACTIVATED ALUMINA
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Effluent Arsenic Conc. (mg/l)	*Activated Alumina dose (mg/L)*								
	200	***300***	***400***	***500***	***750***	***1000***	***1250***	***1500***	***2000***
	Arsenic concentration (mg/L)								
5.3	5.1	5	3.8	2.9	2.1	1.6	1.4	0.8	0.6
2.6	2.5	2.2	1.6	1.4	0.9	0.6	0.5	0.5	0.4

APPENDICES

APPENDIX A

GROUNDWATER COLLECTION, CHARACTERIZATION AND STORAGE

APPENDIX A

GROUNDWATER COLLECTION CHARACTERIZATION AND STORAGE

1. SELECTION OF REPRESENTATIVE WELLS

Based on the analytical results from Pilot Project Treatability Study it was expected that the blended groundwater from wells EW-2 and MW-7D would provide a representative mixture with appropriate target concentrations of ammonia and arsenic. However, unexpected high concentrations of ammonia in the groundwater from wells EW-2 and MW-7D required re-evaluation of water quality to define an appropriate mix of samples.

A careful review of historical analytical data for groundwater at the Site was conducted to select other wells that could supply the groundwater composite with target concentrations of ammonia and arsenic and still be representative in terms of general chemistry and organic contaminants. Additional groundwater flow modelling was also conducted to predict long-term concentrations of target parameters from various wells.

Based on the historical data and modelling three wells: MW-7S, MW-4D and MD-7D were selected for additional evaluation. Field measurements of ammonia concentrations in the groundwater collected from these wells using an ammonia selective electrode confirmed expected concentrations.

On January 6, 2003, 190 gallons of groundwater was collected as follows:

140 gallons from MW-7S
30 gallons from MW-7D
20 gallons from MW-4D

Collected groundwater was placed in 5-gallon plastic pails. The 5-gallon pails were sealed, placed in heavy plastic bags, sealed again, and packed in individual cardboard boxes with adsorptive packing materials for overnight shipment to the CRA Treatability Laboratory in Waterloo, Ontario.

As the nitrification study was extended from the originally planned 27 weeks to 39 weeks two additional groundwater collections from the same wells were also conducted.

In the Treatability Laboratory composite samples, prepared from the same volume of water from each container were prepared:

i) Composite MW-7S: 500 ml from each of 28 containers containing groundwater from this well;

ii) Composite MW-7D: 500 ml from each of 6 container containing groundwater from this well; and

iii) Composite MW-4D: 500 ml from each of 4 containers containing groundwater from this well.

A sub-sample of the blended mixture was sent to EnviroTest Analytical Laboratory in Waterloo, Ontario. The samples were analysed, consistent with the Work Plan, for the following parameters: pH, ORP, total suspended solids (TSS), turbidity, conductivity, chemical oxygen demand (COD), soluble COD (SCOD), total organic carbon (TOC), dissolved organic carbon (DOC), ammonia, nitrate, phosphates, cyanide, phenols, arsenic, thiocyanate, and base/neutral, and acid extractable organic compounds. Results of these analyses are presented in Table 2.1 of the main text.

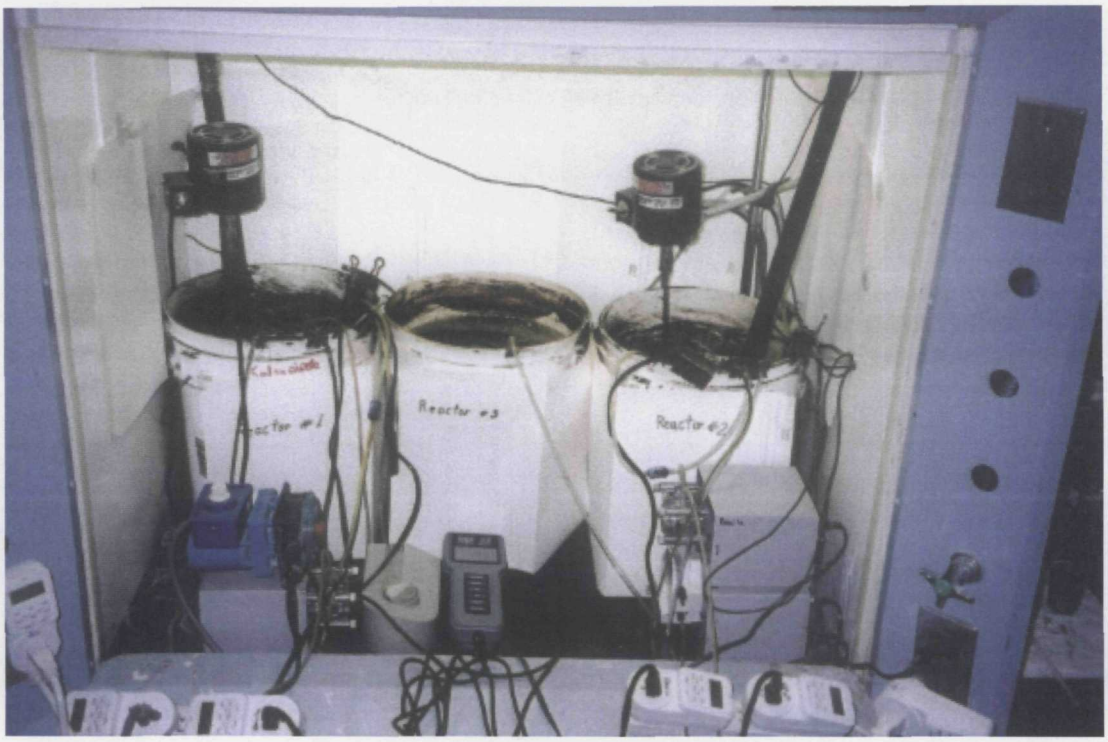
To ensure the same groundwater quality during the study the following procedure was applied:

1. groundwater samples were kept at ~ 5°C and well mixed before the treatment;
2. samples for treatment were collected in equal volumes from each storage containers; and
3. before treatment each batch sample (comprised of the same ratio of the groundwater from each well) were analysed for the following parameters: pH, TSS, VSS, COD, TOC, DOC, ammonia, nitrate, cyanide, phenols, arsenic, thiocyanate.

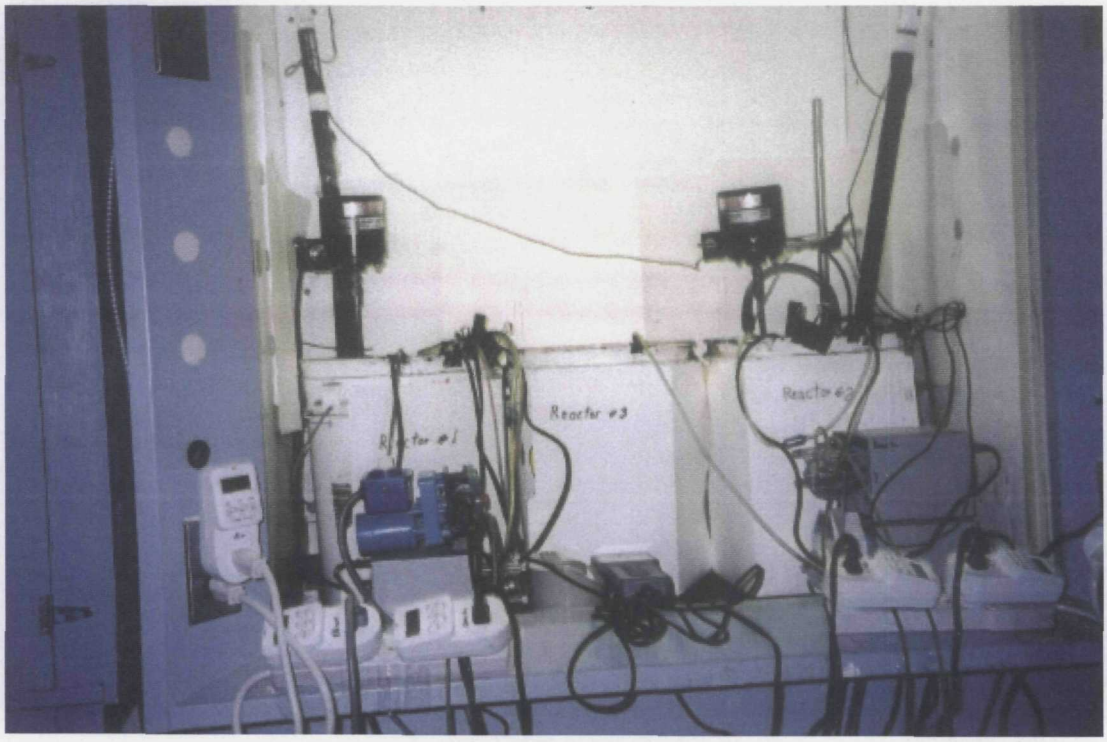
APPENDIX B

PHOTOGRAPHS OF BENCH APPARATUS

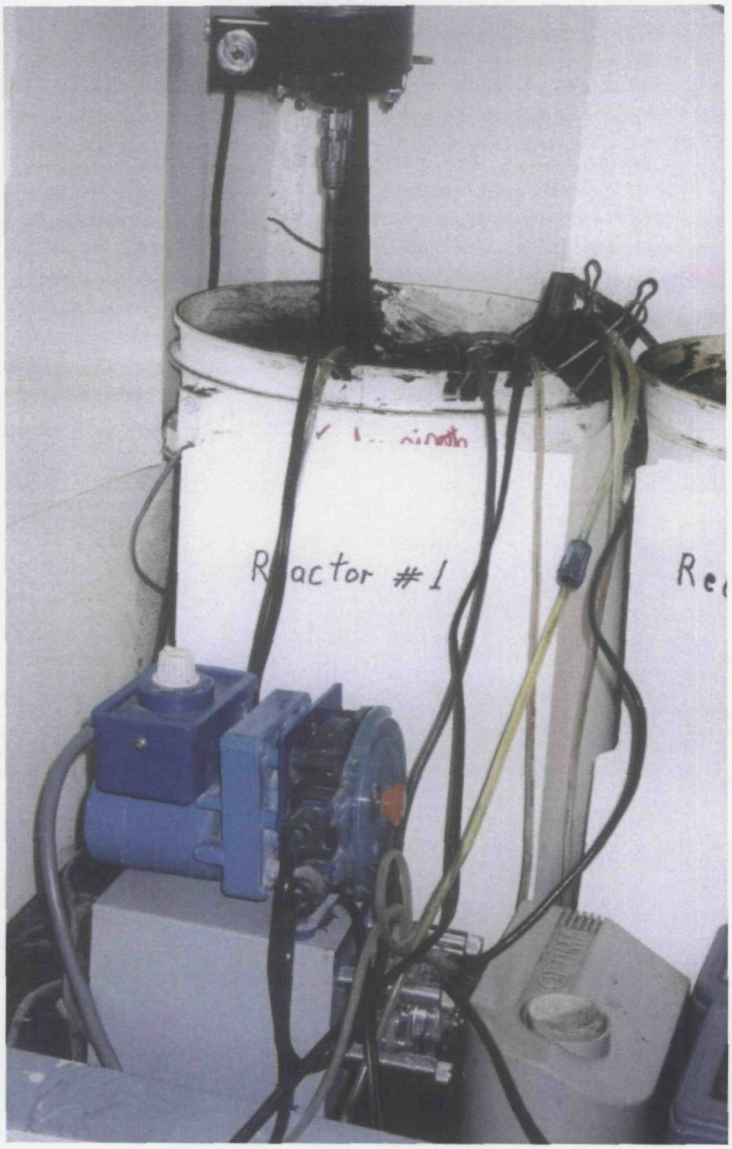
PHOTOGRAPHS



Photograph 1. A general view of the biological treatment system showing two working reactors SBR-1 and SBR-2 and the back up reactor # 3.



Photograph 2. Two working reactors SBR-1 and SBR-2 with dedicated peristalic pumps and timers.

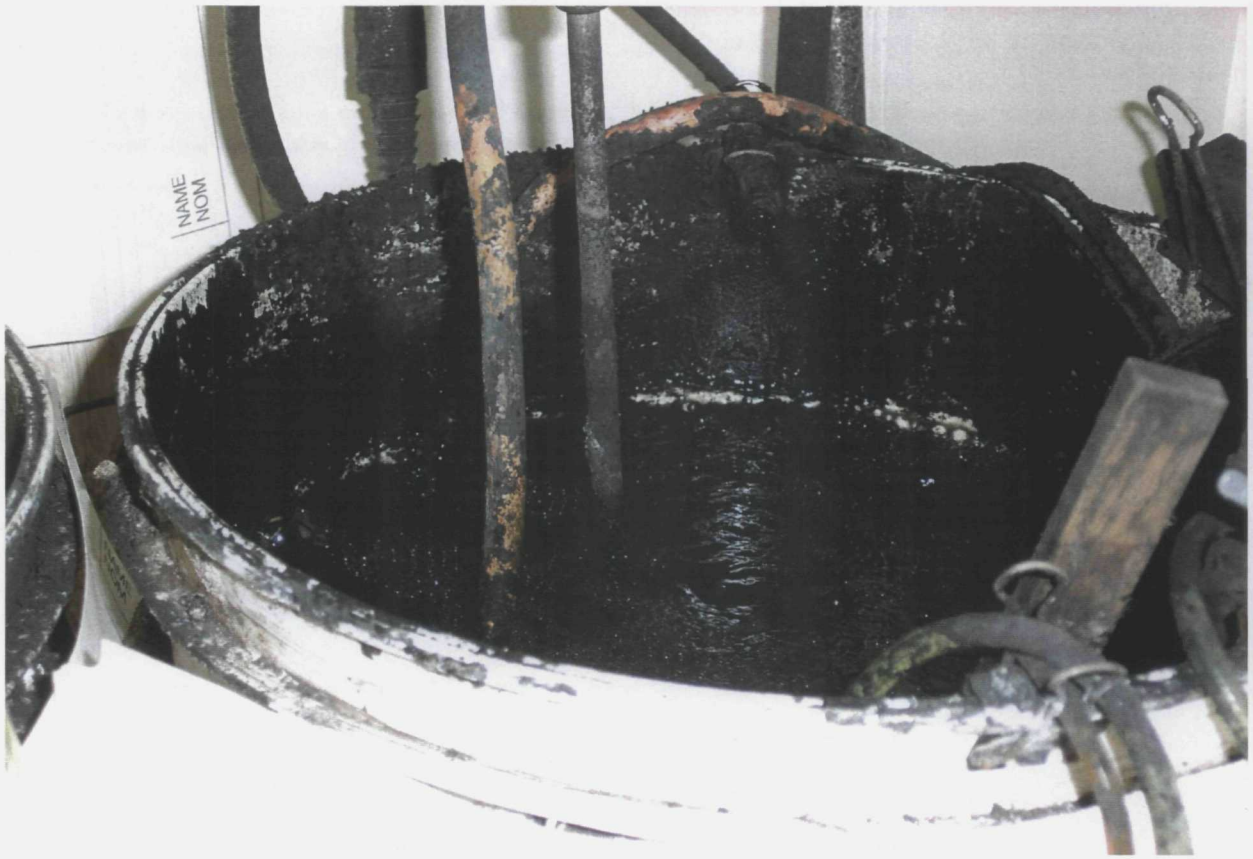


Photograph 3. The reactor SBR-1 with the influent and the effluent pump.

Photograph 4. The reactor SBR-2 with the mixer, the cooling coil, the aeration equipment and a pH electrode connected to the controller (not in the photograph.

Photograph 5. The reactor SBR-1 with the mixer, the aeration equipment and the feed tubing.

Photograph 6. Peristaltic pumps and timers controlling their operation.



Photograph 7. The close view of the reactor SBR-2 with the mixer and the cooling coil.

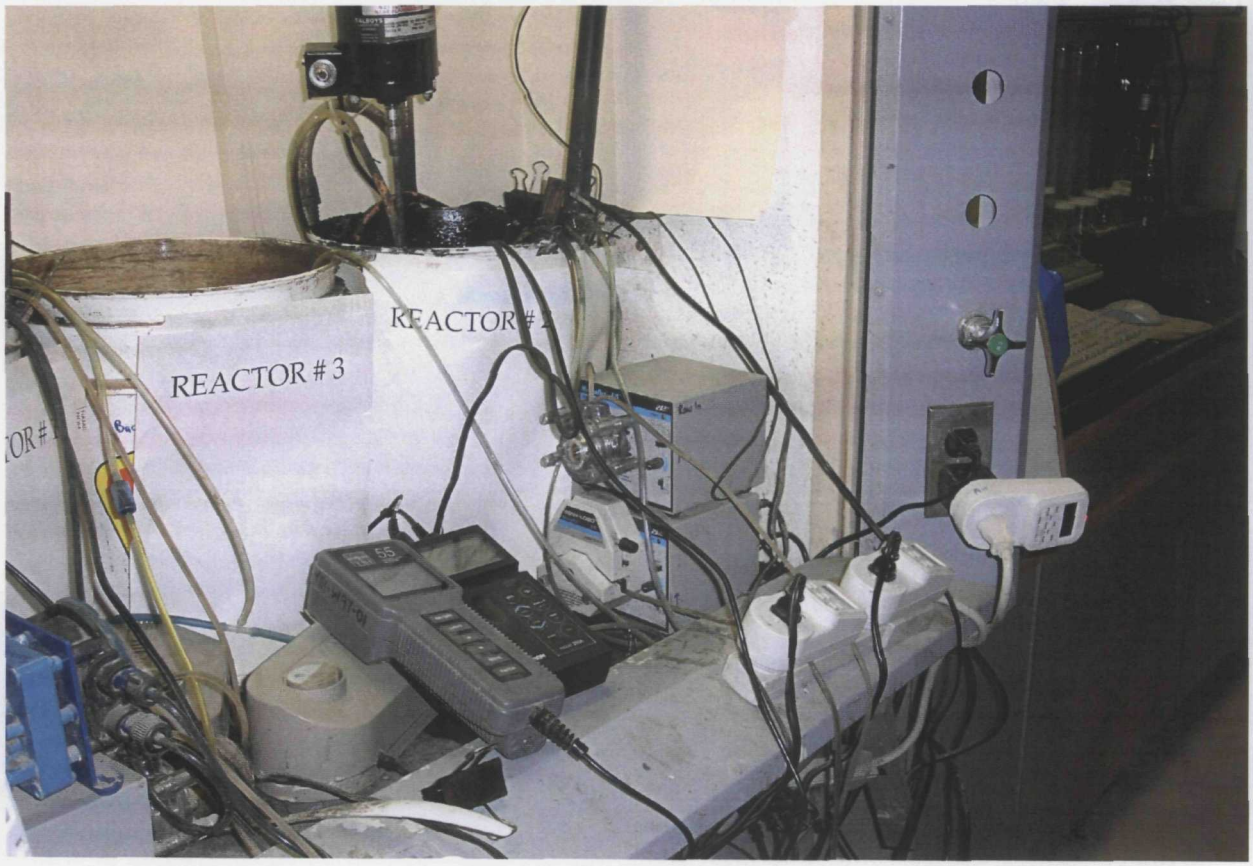
Photograph 8. DO meter and pH meter used to monitor SBR operation.

Photograph 9. The general view of the treatment system set up with the influent and the effluent (at the bottom) tanks.

Photograph 10. A close view of the heater and the aeration system.

Photograph 11. PH controllers with soda ash jars.

Photograph 12. The close view of pH controller.



Photograph 13. Reactors SBR-2 and SBR-3 with pumps, timers and monitoring equipment.

APPENDIX C

COMPARISON OF LABORATORY AND AMMONIA/AMMONIUM SELECTIVE ELECTRODE MEASUREMENTS

TABLE C

RESULTS OF AMMONIA MEASUREMENTS IN THE LABORATORY AND USING ION SELECTIVE ELECTRODE

Date	*Sample*	*Laboratory result (mg/L as NH3-N)*	*Electrode Measurements (mg/L as NH3-N)*	*Deviation*	
				value	*(%)*
10-Jan	MW-4D	2600	2200	400	15.4
	MW-7D	2500	2100	400	16.0
	MW-7S	0.42	0.45	0.03	7.1
13-Jan	SBR-1 Influent	33.6	31.2	2.4	7.1
			31.5	2.1	6.3
			31.1	2.5	7.4
14-Jan	SBR-1 ML	16.8	17.6	0.8	4.8
			15.5	1.3	7.7
			16.1	0.7	4.2
15-Jan	SBR-1 ML	19	18.2	0.8	4.2
			19.8	0.8	4.2
			17.8	1.2	6.3
16-Jan	SBR-1 ML	17	18.6	1.6	9.4
			18.2	1.2	7.1
			17.4	0.4	2.4
17-Jan	SBR-1 ML	9.2	10.2	1	10.8
			10.1	0.9	9.8
			9.8	0.6	6.5
18-Jan	SBR-1 ML	22	23.2	1.2	5.4
			22.8	0.8	3.6
			22.6	0.6	2.7

APPENDIX D

ANALYTICAL DATA FOR INDIVIDUAL BATCHES OF RAW AND PRE-TREATED GROUNDWATER

Table D1 - Analyses of raw and pre-treated groundwater - batch 2 (2/28/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as N (mg/L)	662	602	9.06
COD (mg/L)	1300	1200	7.69
DOC (mg/L)	436	406	6.88
Phenol (4AAP) (mg/L)	130	120	7.69
Thiocyanate (mg/L)	88	66	25.00
TKN (mg/L)	790	720	8.86
Total Cyanide (mg/L)	2.40	1.6	33.33
Total Organic Carbon (mg/L)	412	392	4.85
Total Suspended Solids (mg/L)	3.0	<1.0	–
Volatile Suspended Solids (mg/L)	2	<1	–
Arsenic (mg/L)	6.6	1	84.85

Table D2 - Analyses of raw and pre-treated groundwater - batch 3 (3/27/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix	Removal(%)
Ammonia as NH3-N	521	518	0.58
COD	1300	1200	7.69
DOC	346	333	3.76
Phenol	158	122	22.78
Thiocyanate	200	160	20.00
TKN	600	550	8.33
Total Cyanide	3.60	1.3	63.89
Total Organic Carbon	374	350	6.42
Total Suspended Solids	2.3	9.5	–
Volatile Suspended Solids	2	1	–
Arsenic	6.6	0.70	89.39

Table D3 - Analyses of raw and pre-treated groundwater - batch 4 (4/12/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	568	540	4.93
COD	1400	1200	14.29
DOC	348	315	9.48
Phenol	138	124	10.14
Thiocyanate	170	160	5.88
TKN	820	760	7.32
Total Cyanide	3.50	2.6	25.71
Total Organic Carbon	367	334	8.99
Total Suspended Solids	8.0	2.4	–
Volatile Suspended Solids	7	2	–
Arsenic	6.8	1.2	82.35

Table D4 - Analyses of raw and pre-treated groundwater - batch 5 (4/21/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	634	580	8.52
COD	1260	1210	3.97
DOC	343	338	1.46
Phenol	170	104	38.82
Thiocyanate	150	140	6.67
TKN	830	790	4.82
Total Cyanide	3.50	2.9	17.14
Total Organic Carbon	367	337	8.17
Total Suspended Solids	6	6	–
Volatile Suspended Solids	3	2	–
Arsenic	6.4	0.95	85.16

Table D5 - Analyses of raw and pre-treated groundwater - batch 6 (5/6/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	630	610	3.17
COD	1380	1300	5.80
DOC	363	346	4.68
Phenol	190	112	41.05
Thiocyanate	180	160	11.11
TKN	810	770	4.94
Total Cyanide	3.7	2.9	21.62
Total Organic Carbon	376	352	6.38
Total Suspended Solids	6	12	–
Volatile Suspended Solids	5	6	–
Arsenic	6.8	1.1	83.82

Table D6a) - Analyses of raw and pre-treated groundwater - batch 7 (5/19/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	610	610	0.00
COD	1300	1150	11.54
DOC	390	346	11.28
Phenol	112	90	19.64
Thiocyanate	160	150	6.25
TKN	770	760	1.30
Total Cyanide	4.7	2.9	38.30
Total Organic Carbon	490	422	13.88
Total Suspended Solids	6	12	–
Volatile Suspended Solids	5	6	–
Arsenic	6.2	1.1	82.26

Table D6b) - Analyses of raw and pre-treated groundwater - batch 7 (5/26/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	615	610	0.81
COD	1350	1300	3.70
DOC	390	346	11.28
Phenol	112	90	19.64
Thiocyanate	170	160	5.88
TKN	790	770	2.53
Total Cyanide	4.8	2.9	39.58
Total Organic Carbon	490	372	24.08
Total Suspended Solids	6	12	–
Volatile Suspended Solids	5	6	–
Arsenic	6.2	0.91	85.32

Table D7 - Analyses of raw and pre-treated groundwater - batch 8 (5/30/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	578	560	3.11
COD	1350	1210	10.37
DOC	390	342	12.31
Phenol	110	102	7.27
Thiocyanate	160	146	8.75
TKN	690	670	2.90
Total Cyanide	4.3	2.6	39.53
Total Organic Carbon	430	392	8.84
Total Suspended Solids	20	12	–
Volatile Suspended Solids	15	6	–
Arsenic	6.8	0.82	87.94

Table D8 - Analyses of raw and pre-treated groundwater - batch 9 (6/12/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	610	590	3.28
COD	1380	1200	13.04
DOC	360	348	3.33
Phenol	120	92	23.33
Thiocyanate	160	142	11.25
TKN	690	660	4.35
Total Cyanide	3.6	2.2	38.89
Total Organic Carbon	410	389	5.12
Total Suspended Solids	20	12	–
Volatile Suspended Solids	13	9	–
Arsenic	6.6	0.92	86.06

Table D9 - Analyses of raw and pre-treated groundwater - batch 10 (6/17/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	520	490	5.77
COD	1300	1180	9.23
DOC	340	290	14.71
Phenol	190	97	48.95
Thiocyanate	200	180	10.00
TKN	570	510	10.53
Total Cyanide	3.8	2.8	26.32
Total Organic Carbon	420	240	42.86
Total Suspended Solids	20	22	–
Volatile Suspended Solids	15	14	–
Arsenic	9.2	0.92	90.00

Table D10 - Analyses of raw and pre-treated groundwater - batch 11 (6/27/03)

Parameter(mg/L)	Raw mix (R1)	Pre Treated mix(R2)	Removal(%)
Ammonia as NH3-N	530	500	5.66
COD	1700	1200	29.41
DOC	300	240	20.00
Phenol	200	140	30.00
Thiocyanate	180	76	57.78
TKN	790	650	17.72
Total Cyanide	3.2	2.9	9.38
Total Organic Carbon	380	300	21.05
Total Suspended Solids	104	180	–
Volatile Suspended Solids	65	98	–
Arsenic	9.6	1.9	80.21

APPENDIX E

DAILY OPERATION SUMMARY

TABLE E1A

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION - CLAIRTON SLUDGE
SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters						TKN load (mg/L)#	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif	NH3-nitr/VSS (mg/L)	Comments
		pH (St U)	DO (mgO2/L)	EC (15 mm)	Feed (ml) Water	Feed (ml) Groundwater	Temperature (oC)		COD	NH3-N (*)	NO3-N	TSS	VSS				
Feb-09	9:00	7.3	5.4	2.3			25			3.2							no feed
	18:00	7.6	5.8	2.4			27			3.1				14000/21200			no feed
Feb-10	9:00	7.8	5.6	2.3			27			2.8				R =0.66			
	18:00	7.4	5.8	2.2			27			2.6							
Feb-11	9:30	7.8	5.2	2.7	2700	300	27	26.2		2.3					26.5		
	18:00	7.3	5.8	2.6			27			2.2							
Feb-12	9:30	7.9	5.4	1.9	2600	400	26	34.9		0.2					35.4		
	18:00	7.3	6.2	3.4			26			0.3							
Feb-13	9:30	7.4	5.2	2.1	2500	500	26	43.5		0.3					45.6		0.5 g Na2CO3
	18:00	7.2	5.8	2.6			26			0.6							
Feb-14	9:30	7.8	5.6	2.2	2400	600	26	52.0	130	0.3	96			15000/21800	51.9		0.8 g Na2CO3
	17:30	.8	5.8	2.4			26			0.35				R = 0.688			
Feb-15	9:00	7.6	5.4	2.3	2300	700	26	60.7	220	0.4	98				60.7		1.0 g Na2CO3
	18:00	7.5	5.5	2.2			26			0.2							
Feb-16	9:00	7.6	5.6	2.1	2200	800	28	69.4	240	0.15	103				69.3		poor settling, flocculants added
	17:30	7.2	5.9	2.5			28			0.2							
Feb-17	9:00	7.3	6.2	2.1	2100	900	28	78.0	280	0.16	110	103	76		78.3		1.0 g Na2CO3, flocculant
	17:30	7.2	5.8	2.3			28			0.23							
Feb-18	9:30	7.6	5.6	2.2	2000	1000	27	86.7	340	0.5	120	120	88		86.7		2.0 g Na2CO3
	18:00	6.5	5.5	2.4			27			2.2							
Feb-19	9:00	6.7	5.4	2.1	3000	0	26	0.0	320	10.2	110	170	102	19000/26500			2.0 g Na2CO3, no feed
	18:00	6.5	5.8	2.3			27			8.2				R = 0.716			5.0 g Na2CO3, no feed
Feb-20	9:00	7.8	5.6	2.2	3000	0	27	0	135	7.8	102	180	103				5.0 g Na2CO3, no feed
	18:00	7.6	5.6	2.2			27			7.1							
Feb-21	9:30	7.6	6.2	2.2	3000	0	28	0	140	13.6	93	98	60				5.0 g Na2CO3, no feed
	18:00	8.2	5.5	2.4			26			10.2							
Feb-22	8:00	7.6	5.8	2.3	3000	0	26	0	180	16.2	78	176	98				3.0 g Na2CO3, no feed, 2 ml Buffer
	18:00	7.5	5.6	2.2			26			11.9							
Feb-23	8:30	7.8	5.4	1.8	3000	0	26	0	160	14.3	79	170	88				2.0 g Na2CO3, no feed, 2 ml Buffer
	17:30	6.9	5.6	2.2			26			11.2							
Feb-24	9:30	7.2	5.6	2.2	3000	0	26	0	155	6.8	80	120	73	13000/23400			1.0 g Na2CO3, no feed
	17:30	7.8	6.2	2.7			26			10.1				R = 0.684			
Feb-25	9:30	7.6	5.4	2.2	3000	0	26	0	118	11.4	72	110	70				1.0 ml buffer,
	17:00	7.4	5.8	2.3			26			9.2							
Feb-26	9:00	7.6	5.2	1.9	3000	0	26	0	130	8.6	56	46	36				1.0 ml buffer, 300 ml AS R # 3
	17:30	7.3	5.5	2.4			26			8.1							
Feb-27	9:30	7.2	5.6	2.1	3000	0	26	0	110	7.6	42	66	54				1.0 ml buffer, 500 ml As R # 3
	17:00	7.1	6.2	2.6			26			7.8							
Feb-28	8:30	7.9	5.4	2.2	3000	0	26	0	116	8.8	36	63	57				1.0 ml buffer, 500 ml As R # 3
	17:00	7.3	5.5	2.4			27			7.9							
Mar-01	9:00	7.8	5.2	2.2	3000	0	27	0	122	7.8	32	54	46				1.0 ml buffer, 500 ml As R # 3
	17:00	7.5	5.7	2.6			26			7.4							
Mar-02	9:30	7.6	5.4	.8	3000	0	26	0	130	7.2	29	68	59				1.0 ml buffer, 500 ml As R # 3
	17:00	7.4	5.9	2.5			25			7							
Mar-03	9:30	7.7	5.7	2.6	3000	0	26	0	108	7.2	27	56	48	9300/13800			1.0 ml buffer, 500 ml As R # 3
	17:30	7.3	6.5	1.9			25			3.8				R = 0.674			
Mar-04	8:30	7.4	5.3	2.7	2800	200	25	10.5	120	0.5	34	48	42			0.0024	New Feed, 1.0 ml buffer
	17:30	8.1	6.2	2.6			26			0.6							
Mar-05	8:30	7.8	5.4	2.2	2700	300	26	15.8	86	0.8	36	53	47		22.5	0.0017	1.0 ml buffer
	17:00	7.8	5.5	2.4			26			0.7							
Mar-06	9:00	7.9	5.2	2.2	2700	300	27	15.8	84	0.9	39	49	38		15.5	0.0017	1.0 ml buffer
	17:00	7.6	5.7	2.6			27			0.4							
Mar-07	9:30	7.8	5.4	1.8	2700	300	26	15.8	71	0.15	41	23	18		15.7	0.0018	1.0 ml buffer
	17:00	7.7	6.2	2.6			26			0.22							
Mar-08	9:30	7.8	5.4	2.2	2700	300	26	15.8	74	0.18	45	39	32	7700/12000	16.6	0.0020	1.0 ml buffer
	17:30	8.1	5.5	2.4			26			0.54				R =0. 641			1.0 ml H3PO4

TABLE E1A

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION - CLAIRTON SLUDGE
SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters							Effluent Analytical Data (mg/L)					MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	Comments
		pH (Std U)	DO (mg O2/L)	DO(15 min)	Feed (ml)		Temperature	TKN load (mg/L)#	COD	NH3-N (*)	NO3-N	TSS	VSS	Ratio		(mg/L)	
					Water	Groundwater	(oC)										
Mar-09	8:30	8	5.2	2.2	2700	300	26	15.8	69	0.6	48	46	41		15.8	0.0020	
	17:30	8.1	5.7	2.6			26			0.8							
Mar-10	9:00	7.8	5.4	1.8	2700	300	27	15.8	59	0.3	52	19	16		15.4	0.0021	additional heater & aerator
	18:00	7.9	5.9	2.5			27			0.22							pH controllers calibrated
Mar-11	9:00	7.7	5.7	2.6	2700	300	28	15.8	60	0.16	56	31	26		16.1	0.0021	
	17:30	7.8	6.5	1.9			28			0.2							1.0 ml buffer
Mar-12	9:00	8.1	5.8	2.4	2700	300	27	15.8	62	0.4	58	44	32		15.9	0.0027	
	17:00	7.8	5.7	2.5			27			0.22							
Mar-13	9:00	7.6	5.4	5.4	1600	400	27	21.1	58	0.25	64	23	20		20.8	0.0028	
	16:30	7.7	6.2	6.2			27			0.18							
Mar-14	8:30	7.8	5.4	5.4	1600	400	27	21.1	45	0.28	68	17	10		21.2	0.0027	
	17:00	7.7	5.5	5.5			27			0.32							
Mar-15	9:00	7.6	5.2	5.2	1550	400	27	21.1	49	0.38	72	35	27		21.0	0.0031	
	17:00	7.6	5.7	5.7			27			0.24							
Mar-16	9:00	7.5	5.8	5.8	1550	450	26	23.7	52	0.2	74	42	36		23.6	0.0031	
	16:30	7.6	5.7	5.7			27			0.28							
Mar-17	9:00	7.7	5.7	5.7	1500	450	27	23.7	48	0.16	81	33	28	7600/11900	23.9	0.0035	
	17:30	7.6	6.6	6.6			28			0.44				R = 0.638			
Mar-18	8:30	7.5	6.5	6.5	1400	500	28	26.3	53	0.12	88	25	18		26.4	0.0042	
	18:00	7.6	6.4	6.4			28			0.77							
	23:00	7.6	6.4	6.4			28			0.8					31.6		
Mar-19	8:30	7.5	6.3	6.3	1300	600	28	31.6	70	0.09	100	55	36			0.0049	
	17:00	7.6	6.6	6.6			27			0.67							
	23:00	7.7	6.5	6.5			27			0.58					37.5		
Mar-20	9:00	7.6	6.4	6.4	1200	700	28	36.9	43	0.2	110	20	15			0.0056	
	17:00	7.6	6.8	6.8			27			0.65							
	23:00	7.6	6.5	6.5			28			0.8					42.6		
Mar-21	9:00	7.5	6.2	6.2	1100	800	28	42.1	49	0.52	120	30	22				500 ml ML from R#3
	17:00	7.6	6.4	6.4			28			0.34							
	23:00	7.6	6.4	6.4			29			0.36					47.5		
Mar-22	9:30	7.5	6.5	6.5	1050	900	28	47.4		0.26							
	16:30	7.5	6.4	6.4			28			0.48							
	23:00	7.7	6.3	6.3			28			0.46					50.1		
Mar-23	9:30	7.5	6.5	6.5	1000	950	28	50.0		0.17						0.0078	
	16:00	7.5	6.6	6.6			28			0.37							
	23:00	7.6	6.3	6.3			28			0.42					53.0		
Mar-24	9:00	7.6	6.7	6.7	900	1000	28	52.7	73	0.18	162	6	5	6800/10700		0.0085	
	17:00	7.6	5.8	5.8			29			0.72				R = 0.636			
	23:00	7.5	5.9	5.9			29			0.52					58.1		
Mar-25	9:00	7.5	5.8	5.8	800	1100	29	57.9		0.15						0.0094	
	16:30	7.4	6	6			28			0.68							
	23:00	7.5	5.9	5.9			29			0.3					63.8		
Mar-26	9:00	7.6	6.2	6.2	650	1200	29	63.2		0.14						0.0105	
	17:00	7.6	5.8	5.8			29			0.73							
	23:00	7.6	6.1	6.1			29			0.86					71.6		
Mar-27	9:00	7.5	5.9	5.9	500	1350	29	71.1	67	0.05	180	12	9				
	16:30	7.5	5.8	5.8			29			0.26							
	23:00	7.4	6.2	6.2			29			0.43					79.7		
Mar-28	9:00	7.5	5.8	5.8	400	1500	29	79.0		0.16							
	16:30	7.5	6.3	6.3			29			0.53							
	23:00	7.5	6.4	6.4			28			0.68					84.4		
Mar-29	9:00	7.6	5.9	5.9	300	1600	28	84.3		0.13						0.0138	
	16:30	7.5	7.2	7.2			29			0.23							
	23:00	7.5	6.4	6.4			29			0.46					89.9		

TABLE E1A

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION - CLAIRTON SLUDGE
SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters							Effluent Analytical Data (mg/L)					MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	Comments
		pH (St U)	DO (mg O2/L)	DO(15 min)	Feed (ml)		Temperature	TKN load (mg/L)#	COD	NH3-N (*)	NO3-N	TSS	VSS	Ratio		(mg/L)	
					Water	Groundwater	(oC)										
Mar-30	9:00	7.4	6.3	6.3	200	1700	29	89.5		0.19						0.0145	
	16:30	7.5	5.9	5.9			30			0.38							
	23:00	7.6	5.8	5.8			29			0.42					94.8		
Mar-31	9:30	7.5	6	6	100	1800	29	94.8	58	0.09	190	6	5	6540/10100		0.0153	
	17:00	7.3	7.4	7.4			29			1.9				R =0.648			
	23:00	7.4	6.9	6.9			28			0.82					100.4		
Apr-01	9:00	7.5	7.2	7.2	0	1900	28	100.1		0.2						0.0164	
	16:00	7.3	7	7			28			2.2							
	23:00	7.5	7.2	7.2			28			0.88					107.0		
Apr-02	9:00	7.4	7.2	7.2	0	2000	29	105.3		0.2						0.0132	
	17:00	7.3	7.4				29			3.1							
	23:00	7.4	7.2				29			4.1					86.3		feed disconnected
Apr-03	9:00	7.4	7.3	3.4	0	1600	28	84.3		0.23							
	17:00	7.3	7.5				28			1.5							
	23:00	7.5	7.4				28			2.2					108.2		
Apr-04	9:00	7.4	7.2	3.3	0	2000	29	105.3		0.24							
	16:30	7.4	7.6				28			1.6							
	23:00	7.5	6.9				29			0.96					106.6		
Apr-05	9:00	7.4	7.4	3.3	0	2000	28	105.3		0.16						0.0167	
	17:00	7.5	7.2				29			1.1							
	23:00	7.5	7.6				28			0.88					106.8		
Apr-06	9:00	7.4	7.4	2.9	0	2000	29	105.3		0.23						0.0166	15 g PAC added
	17:00	7.4	7.2				28			0.86							
	23:00	7.5	7.3				28			0.82					106.2		
Apr-07	9:00	7.5	7.8	3.2	0	2000	28	105.3		0.17				6900/10500		0.0166	15 g PAC added
	16:30	7.4	6.9				28			0.18				R = 0.657			
	23:00	7.5	7.4				28			0.68					106.0		
Apr-08	8:30	7.4	7.2	3.4	0	2000	28	105.3		0.14						0.0165	15 g PAC added
	17:00	7.5	7.8				29			1.1							
	23:00	7.4	7.4				28			1.4					105.4		
Apr-09	9:30	7.4	7.2	3.6	0	2000	28	105.3		0.21							

TABLE E1B

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	
		pH (St Un)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS			
Apr-10	9:00	7.6	7.3	3.1	2000	28	105.3		0.18				7300/11700	#REF!	#REF!	<15 g PAC
	17:00	7.4	7.2			28			3.1				R = 0.624			
	23:00	7.5	7.6			29			1.6							
Apr-11	9:00	7.5	7.4	2.9	2000	28	105.3		0.27					105.2	0.01442	<10 g PAC
	16:30	7.4	7.2			29			1.3							
	23:00	7.4	7.3			28			0.89							
Apr-12	8:30	7.5	7.8	2.8	2000	28	105.3		0.05					105.6	0.01100	
	17:00	7.5	7.2			28			1.2							
	23:00	7.4	7.6			28			0.86							
Apr-13	9:00	7.5	7.4	2.9	2000	29	105.3		0.14				9600/13800	105.2	0.01096	100 mL RAS wasted
	17:30	7.4	7.2			28			0.96				R = 0.695			
	23:00	7.4	7.3			29			0.65							
Apr-14	9:00	7.6	7.8	2.6	2000	28	105.3		0.12					105.4	0.01097	100 mL RAS wasted
	17:00	7.3	6.9			28			0.28							
	23:00	7.4	7.4			28			0.32							
Apr-15	9:00	7.4	7.2	2.4	2000	28	105.3		0.14					105.3		
	17:30	7.4	7.4			28			0.16							
	23:00	7.5	7.3			29			0.63							
Apr-16	9:00	7.4	7.2	2.2	2000	28	105.3		0.12					105.4	0.01301	
	17:00	7.4	7.6			29			0.81							
	23:00	7.5	7.4			28			0.76							
Apr-17	9:30	7.5	7.2	2.6	2000	28	105.3		0.13				8100/11600	105.3	0.01300	
	16:30	7.4	7.3			28			0.92				R = 0.698			
	23:00	7.4	7.8			28			0.64							
Apr-18	9:30	7.5	7.2	2.5	2000	29	105.3		0.15					105.3	0.01300	
	17:00	7.5	6.7			28			0.15							
	23:00	7.4	6.2			28			0.26							
Apr-19	9:00	7.3	6.4	1.9	2000	29	105.3		0.08					105.4		
	16:00	7.4	6.2			28			0.24							
	23:00	7.4	5.9			29			0.33							
Apr-20	8:30	7.5	6.7	2.8	2000	28	105.3		0.07					105.3	0.01225	
	16:30	7.3	6.2			28			0.22							
	23:00	7.4	6.4			28			0.31							
Apr-21	8:00	7.4	6.7	2.3	2000	29	110.7	40	0.1	380	6	3	8600/12300	105.3	0.01224	
	16:00	7.4	6.2			29			0.17				R = 0.699			
	23:00	7.5	6.4			28			0.32							
Apr-22	9:00	7.5	6.2	1.8	2000	29	110.7		0.15					110.6	0.01286	
	16:00	7.4	5.9			28			0.22							

TABLE E1B

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	
		pH (St Un)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS				
	23:00	7.3	6.7			28			0.28							
Apr-23	8:30	7.4	6.2	2.2	2000	28	110.7		0.14					110.7	0.01333	
	16:30	7.4	6.4			28			0.18							
	23:00	7.5	6.2			29			0.23							
Apr-24	8:30	7.3	5.6	1.7	2000	29	110.7		0.12				8300/11900	110.7	0.01334	
	16:30	7.3	5.9			29			1.2				R = 0.697			
	23:00	7.4	6.1			29			0.68							
Apr-25	9:00	7.4	6.2	1.6	2000	29	110.7		0.14					110.6	0.01333	Additional Air pump
	16:30	7.3	5.9			28			0.32							
	23:00	7.4	5.8			28			0.68							
Apr-26	8:30	7.3	6.1	1.4	2000	28	110.7		0.24					110.6	0.01332	
	18:00	7.3	5.9			28			0.42							
Apr-27	9:30	7.3	6.2	2.2	2000	28	110.7		0.16					110.7		
	18:00	7.4	5.9			28			0.76							
Apr-28	8:30	7.3	5.7	1.8	2000	28	110.7		0.12					110.7		
	16:30	7.3	5.8			29			0.83							
	23:00	7.3	6.3			29			0.46							
Apr-29	9:00	7.4	6.9	2.3	2000	29	110.7	38	0.1	440	6	4		110.7		Air flow adjustment
	17:00	7.4	6.6			29			0.62							
	23:00	7.4	5.6			29			0.23							
Apr-30	8:30	7.3	5.9	2.2	2000	29	110.7		0.08					110.7	0.01401	
	18:00	7.4	6.1			28			0.26							
	23:00	7.3	6.2			28			0.32							
May-01	8:30	7.3	5.9	1.9	2000	28	110.7		0.07				7900/11100	110.7	0.01401	
	16:30	7.3	5.6			28			0.13				R = 0.71			
	23:00	7.4	5.9			28			0.24							
May-02	8:30	7.3	6.1	2.1	2000	29	110.7		0.1					110.6	0.01400	
	18:00	7.4	6.2			29			0.14							
	23:00	7.3	5.9			28			0.22							
May-03	9:00	7.3	5.8	2.2	2000	28	110.7		0.08					110.7		
	17:00	7.3	6.1			28			0.12							
May-04	9:00	7.4	5.9	1.8	2000	29	110.7		0.05					110.7	0.01419	
	17:00	7.3	6.2			29			0.16							
	23:00	7.4	5.7			28			0.18							
May-05	9:00	7.3	5.6	1.3	2000	28	110.7		0.1				7800/11600	110.6	0.01418	
	17:00	7.3	5.4			28			0.14				R = 0.672			Air flow adjustment
	23:00	7.4	5.9			29			0.2							
May-06	8:30	7.4	6.3	2.1	2000	29	110.7	46	0.09	470	6	5		110.7	0.01419	

TABLE E1B

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	
		pH (St Un)	DO (mg/O2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS				
	16:30	7.3	5.9			29		0.1								
	23:00	7.4	5.6			29		0.22								
May-07	9:00	7.4	5.9	1.8	2000	28	108.0	0.08						110.7		
	17:00	7.3	6.1			28		0.2								
	23:00	7.4	6.3			28		0.26								
May-08	9:00	7.3	5.9	1.9	2000	28	108.0	0.11						108.0		
	16:30	7.4	5.3			29		0.28								
	23:00	7.4	5.1			29		0.31								
May-09	9:00	7.4	4.3	1.3	2000	29	108.0	0.65						107.5		Diffusers replaced
	17:00	7.3	5.8			29		0.26								Additional Pump
	23:00	7.4	5.9			28		0.29								
May-10	10:00	7.4	6.2	1.9	2000	28	108.0	0.15						108.5		
	23:00	7.3	6.4			30		0.27								
May-11	10:30	7.4	5.9	2.2	2000	29	108.0	0.18						108.0	0.01440	
	22:30	7.4	6.1			29		0.78								
May-12	8:30	7.3	6.2	1.9	2000	29	108.0	0.37					7500/10800	107.8	0.01437	
	17:00	7.4	5.8			28		0.43					R = 0.694			
	23:00	7.3	6.1			28		0.31								
May-13	9:00	7.4	6.2	2.1	2000	30	108.0	0.22						108.2	0.01442	
	17:00	7.4	7.2			28		1.2								
	23:00	7.4	5.7			28		0.56								
May-14	9:00	7.4	7.4	3.1	2000	29	108.0	0.09						108.1	0.01502	
	16:00	7.4	5.9			29		0.24								
	23:00	7.4	6.2			28		0.31								
May-15	8:30	7.4	6.4	1.9	2000	28	108.0	0.08					7200/9800	108.0	0.01500	DO batteries replaced
	16:30	7.3	5.9			28		0.09					R = 0.734			
	23:00	7.4	6.1			29		0.29								
May-16	8:30	7.3	5.9	1.8	2000	29	108.0	0.1						108.0	0.01500	
	16:30	7.4	6.3			29		0.1								
	23:00	7.4	5.8			29		0.25								
May-17	10:00	7.4	4.4	2.3	2000	28	86.7	0.12						108.0	0.01500	
	23:00	7.3	5.7			28		0.28								

TABLE E1C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	
		pH (Std Un)	T C (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS			
May-18	11:00	7.4	5.1	2.2	2000	29	86.7		0.06						
	23:00	7.4	5.9			29			0.23						
May-19	8:00	7.3	5.7	2.3	2000	30	86.7		0.05						0.00000
	16:00	7.3	5.9			29			0.19						
	23:00	7.3	5.8			30			0.31						
May-20	8:00	7.5	5.3	3.3	2000	29	86.7		0.06				7100/9800	86.7	0.01221	pH probes cleaned
	16:00	7.6	6.4			29			0.42				R = 0.724			
	22:00	7.4	5.9			30			0.48							
May-21	9:30	7.3	6.1	2.7	2000	29	86.7	48	0.04	485	11	8		86.7	0.01221	
	17:00	7.3	5.9			30			0.09							
	22:00	7.5	6.3			30			0.22							
May-22	9:00	7.4	5.1	2.2	2000	29	86.7		0.03					86.7	0.01256	
	17:00	7.4	5.9			29			0.11							
	22:00	7.3	5.8			29			0.22							
May-23	9:30	7.4	5.3	2.4	2000	29	86.7		0.05				6900/9700	86.6	0.01255	Diffusers cleaned/replaced
	17:00	7.4	5.4			29			0.09				R = 0.711			
	22:00	7.3	5.9			28			0.18							
May-24	10:00	7.3	5.1	2.5	2000	28	86.7		0.19					86.5	0.01254	Ammonia electrode membrane
	22:00	7.3	5.2			29			0.16							replaced, electrode calibrated
May-25	9:30	7.5	5.3	2.8	2000	29	86.7		0.16					86.7		
	23:00	7.6	5.9			30			0.18							
May-26	8:30	7.5	5.8	2.3	2000	28	86.7		0.12					86.7	0.01294	
	17:00	7.4	5.9			29			0.57							
	22:00	7.3	5.1			29			0.36							
May-27	8:30	7.3	5.9	2.2	2100	29	91.0		0.11				6700/9600	86.7	0.01294	Air flow adjusted
	18:00	7.5	5.9			30			0.35				R = 0.698			HRT = 5 days set up
	23:00	7.6	5.8			29			0.22							
May-28	9:00	7.5	6.3	2.8	2100	29	91.0		0.14					91.0	0.01353	
	17:00	7.6	6.4			30			0.2							
	23:00	7.5	5.9			29			0.28							
May-29	8:00	7.4	6.1	2.6	2200	30	95.3		0.14					91.0	0.01324	
	16:00	7.4	6.1			28			0.64							
	23:00	7.3	5.9			29			0.43							
May-30	8:30	7.3	6.3	2.9	2300	29	99.7		0.11				7200/10700	95.4	0.01375	Air flow adjusted
	17:00	7.3	6.1			29			0.61				R = 0.673			Additional pump connected
	23:00	7.5	6.1			30			0.32							
May-31	10:00	7.6	5.9	2.4	2300	28	99.7		0.71					99.1	0.01375	
	23:00	7.4	6.3			29			0.23							
Jun-01	9:00	7.3	6.1	2.8	2400	29	104.0		0.06					100.3	0.01393	
	23:00	7.3	5.9			29			0.19							
Jun-02	9:00	7.3	5.8	2.1	2500	30	108.3		0.07					104.0	0.01465	
	18:00	7.5	6.1			29			0.09							
	23:00	7.4	5.9			30			0.14							
Jun-03	9:00	7.4	6.3	2.4	2600	28	112.7		0.04				7100/10500	108.4	0.01525	Air flow adjusted
	18:00	7.3	6.1			29			0.12				R = 0.676			2 diffusers replaced
	23:00	7.3	5.9			29			0.19							
Jun-04	8:30	7.3	6.2	1.9	2700	29	117.0		0.07					112.6	0.01586	
	17:00	7.3	6.4			28			0.05							
	23:00	7.3	6.1			29			0.09							
Jun-05	9:00	7.5	5.7	1.8	2800	29	121.3		0.08					117.0	0.01643	
	17:00	7.3	6.1			28			0.82							
	23:00	7.3	5.9			29			0.28							
Jun-06	9:30	7.3	5.8	1.6	3000	29	130.0		1.2					120.2		100 % feed at 5 HRT
	17:00	7.5	6.1			29			0.8							
	23:00	7.3	5.9			28			0.16							
Jun-07	10:00	7.3	6.1	1.8	3000	28	130.0		0.68					130.5		
	23:00	7.3	5.9			29			0.46							
Jun-08	9:00	7.5	5.8	1.5	3000	29	124.0		0.07					130.6	0.01789	
	23:00	7.4	6.3			29			0.18							

TABLE E1C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)					MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (Unit)	DO (mgO2/L)	DO 15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Jun-09	8:3	7.4	5.9	1.4	3000	28	124.0	0.96					7300/10800	123.1	0.0.686	
	17:(	7.3	6.1			28		0.05					R = 0.675			
	23:(	7.5	5.9			28		0.25								
Jun-10	8:3	7.4	6.1	1.3	3000	29	124.0	0.06						124.9	0.01711	1 L ML taken to R # 2
	17:(	7.4	5.9			28		0.08								1 L make up water added
	22:(	7.4	5.8			28		0.09								
Jun-11	8:3	7.5	5.5	1.8	3000	29	124.0	0.06						124.0		
	5:3	7.3	6.1			28		0.05								
	23:(	7.3	5.9			28		0.09								
Jun-12	8:3	7.3	5.8	1.6	3000	29	124.0	0.08						124.0	0.01722	
	17:(	7.5	6.1			29		0.09								
	22:(	7.4	5.9			29		0.07								
Jun-13	9:0	7.4	6.3	1.9	3000	28	124.0	0.06					7200/9500	124.0	0.01723	
	17:(	7.3	6.1			28		0.09					R = 0.757			
	23:(	7.3	5.9			28		0.08								
Jun-14	8:3	7.3	6.2	1.9	3000	29	124.0	0.07						124.0	0.01722	
	23:(	7.5	6.4			28		0.09								
Jun-15	9:0	7.4	6.1	2.1	3000	28	124.0	0.06						124.0	0.01722	
	22:(	7.4	5.7			28		0.08								
Jun-16	8:3	7.3	6.1	1.9	3000	29	124.0	0.05						124.0		
	17:(	7.3	5.9			29		0.06								
	23:(	7.3	5.8			29		0.08								
Jun-17	8:3	7.3	6.1	1.8	3000	28	104.0	0.04						124.0	0.02000	250 ml of ML wasted for analyses
	17:(	7.3	5.9			28		0.09								Air flow adjusted
	22:(	7.5	5.8			28		0.08								
Jun-18	8:3	7.3	5.9	1.6	3000	29	104.0	0.06					6200/9050	104.0	0.01677	
	17:(	7.4	5.9			28		0.14					R = 0.685			
	22:(	7.4	5.8			29		0.07								
Jun-19	8:3	7.3	5.9	1.8	3000	29	104.0	0.05						104.0	0.01673	
	17:(	7.3	5.9			29		0.06								
	22:(	7.3	5.8			28		0.09								
Jun-20	8:3	7.4	5.9	1.7	3000	28	104.0	0.08						104.0	0.01677	250 ml of ML wasted for analyses
	17:(	7.4	6.2			29		0.04								
	23:(	7.3	5.8			29		0.07								
Jun-21	10:(	7.3	6.1	1.9	3000	29	104.0	0.05						104.0		250 ml of ML wasted for analyses
	23:(	7.3	5.7			28		0.06								
Jun-22	9:0	7.3	6.1	1.8	3000	28	104.0	0.03						104.0		250 ml of ML wasted for analyses
	23:(	7.3	5.9			28		0.05								
Jun-23	9:0	7.4	6	2.1	3000	29	158.0	0.04						104.0	0.01857	200 ml of ML wasted
	17:(	7.4	5.9			29		0.06								
	22:(	7.3	6.1			30		0.04								
Jun-24	9:0	7.4	5.8	1.8	3000	29	158.0	0.05						158.0	0.02821	200 ml of ML wasted for analyses
	17:(	7.4	5.9			30		0.04								
	22:(	7.3	5.9			30		0.04								
Jun-25	9:0	7.3	5.8	1.6	3000	30	158.0	0.05						158.0	0.02821	200 ml of ML wasted
	17:(	7.3	5.9			29		0.06								
	22:(	7.3	5.9			30		0.03								
Jun-26	9:0	7.3	5.8	1.7	3000	29	158.0	0.05					5600/7500	158.0	0.02821	200 ml of ML wasted
	17:(	7.5	5.9			29		0.04					R = 0.746			
	22:(	7.3	5.2			30		0.06								
Jun-27	9:0	7.4	5.8	1.6	3000	29	158.0	0.04						158.0		250 ml of ML wasted for analyses
	17:(	7.4	5.9			30		0.05								
	22:(	7.3	5.9			30		0.05								
Jun-28	10:(	7.3	5.8	1.8	3000	30	158.0	0.04						158.0		250 ml of ML wasted for analyses
	23:(	7.3	5.9			29		0.04								
Jun-29	8:3	7.4	5.9	1.6	3000	29	158.0	0.05						158.0	0.02926	200 ml of ML wasted
	22:(	7.4	5.8			30		0.06								

TABLE E1C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (Std Un)	EC (mgO2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Jun-30	9:0	7.3	5.9	1.6	3000	29	158.0	0.03					5400/7200	158.0	0.02926	
	17:00	7.3	5.9			30		0.05					R = 0.75			
	22	7.3	5.8			30		0.04								
Jul-01	8:3	7.3	5.9	1.7	3000	30	158.0	0.06						158.0	0.02925	200 ml of ML wasted
	22	7.3	5.9			29		0.04								
Jul-02	9:0	7.4	5.8	1.8	3000	30	158.0	0.03						158.0	0.02926	
	17:00	7.4	5.9			30		0.04								
	22:00	7.4	6.2			30		0.07								
Jul-03	9:0	7.3	5.8	1.7	3000	30	158.0	0.03						158.0		200 ml of ML wasted
	17:00	7.3	5.8			30		0.03								
	22:00	7.3	5.9			30		0.08								
Jul-04	8:3	7.4	5.9	1.6	3000	30	158.0	0.02						158.0		
	17:00	7.4	5.8			29		0.03								
	23:00	7.4	5.9			30		0.05								
Jul-05	9:0	6.2	5.9	2.5	1000	30	52.7	1.5						156.5	0.03261	pH probe mulfunction, soda ash overfeed
	22:00	7.4	6.3			31		0.08								raw feed stopped, feed with water
Jul-06	8:3	7.3	5.8	2.1	2000	30	105.3	0.04						54.1	0.01123	pH adjusted with H3PO4
	23:00	7.3	6.1			29		0.05								Foaming
Jul-07	8:3	7.9	5.9	1.7	1000	30	39.3	1.2					4800/6300	104.2	0.02170	raw feed stopped, feed with water
	14:00	6.1	6.1			30		46.5					R = 0.761			pH adjusted with H3PO4
	17:00	6.2	5.9			30		4.8								pH adjusted with H3PO4
	22:00	7.6	5.9			30		1.2								
Jul-08	9:0	7.8	6.3	3.2	1000	30	39.3	0.36						42.9	0.00894	pH adjusted with H3PO4
	17:00	7.9	5.9			30		1.6								feed reduced
	22:00	7.8	6.1			30		0.43								5 g PAC added
Jul-09	8:3	6.6	5.9	2.9	1000	29	39.3	0.14						40.6		pH adjusted with H3PO4
	17:00	6.2	6			30		0.78								feed reduced
	23:00	7.6	5.9			30		0.83								
Jul-10	8:3	7.6	5.8	2.8	1000	30	39.3	2.3						40.0		feed reduced
	17:00	7.5	5.9			30		0.8								
	22:00	7.7	5.8			30		0.3								
Jul-11	9:0	7.3	5.9	3.3	1100	30	43.3	1.2						37.8		feed increased
	17:00	7.4	5.9			30		0.2								
	22:00	7.5	5.8			30		0.6								
Jul-12	9:0	7.4	5.9	2.9	1200	30	47.2	0.08						42.3	0.00829	5 g PAC added
	22:00	7.3	5.8			29		0.16								pH adjusted with H3PO4
Jul-13	9:0	7.3	5.9	2.8	1200	30	47.2	0.36					5100/7100	47.2	0.00925	
	22:00	7.4	5.9			30		0.21					R = 0.718			
Jul-14	8:3	7.3	5.8	2.7	1300	30	51.1	0.22						47.2	0.00925	
	17:00	7.4	5.9			31		0.09								
	23:00	7.3	6.2			30		0.07								
Jul-15	8:3	7.3	5.8	2.5	1400	30	55.1	0.11						51.2		
	17:00	7.6	5.9			30		0.1								
	23:00	7.6	5.8			30		0.3								
Jul-16	9:0	7.5	5.9	2.2	1600	30	62.9	0.16						55.0	0.00834	15 g PAC added
	17:00	7.7	5.8			30		0.13								
	23:00	7.3	5.9			30		0.14								
Jul-17	9:0	7.4	5.9	2.2	1800	29	70.8	0.18					6600/8700	62.9	0.00953	15 g PAC added
	17:00	7.6	5.8			30		0.09					R = 0.758			
	23:00	7.6	5.9			30		0.21								
Jul-18	9:0	7.5	5.8	2.1	2000	30	78.7	0.08						70.9	0.01074	15 g PAC added
	17:00	7.7	5.9			30		0.09								
	23:00	7.6	5.9			30		0.12								
Jul-19	9:0	7.6	6.1	2.2	2200	30	86.5	0.06						78.7		10 g PAC added
	22:00	7.5	6.1			30		0.09								1 L ML exchange with R# 2
Jul-20	8:0	7.7	5.8	2.1	2300	31	90.5	0.02						86.6	0.01056	1 L ML exchange with R# 2
	22:00	7.3	5.9			30		0.08								

TABLE E1C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (Std Un)	DC (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS VSS	Ratio	(mg/L)	(mg/mg)	
Jul-21	8:3	.4	5.8	1.9	2500	30	98.3	0.04				8200/10500	90.4	0.01103	1 L ML exchange with R# 2
	17 :0	.3	5.8			30		0.08				R = 0.780			
	23 :0	.4	5.9			25		0.06							
Jul-22	9:0	.6	5.5	1.4	2700	30	147.6	0.04					98.3	0.01199	Heater replaced
	17 :0	.3	6.5			30		0.03							Aerators replaced
	23 :0	.3	6.6			30		0.06							
Jul-23	9:0	.4	6.8	2.5	3000	30	164.0	0.03					147.6	0.01801	Air flow adjusted, DO calibrated
	17 :0	.3	6.4			30		0.04							
	23 :0	.4	6.6			30		0.02							
Jul-24	9:0	.3	6.4	2.3	3000	30	164.0	0.08					164.0	0.01906	
	17 :0	.6	7.6			30		0.04							
	23 :0	.6	7.8			30		0.02							
Jul-25	9:0	.5	7.7	3.2	3000	30	164.0	0.08				8600/10700	164.0	0.01907	Wasted 150 ml ML
	17 :0	.7	7.5			30		0.04				R = 0.803			
	23 :0	.3	7.3			30		0.08							
Jul-26	9:0	.4	7.8	3.8	3000	30	134.0	0.06					164.0	0.01907	Wasted 150 ml ML
	22 :0	.6	7.7			30		0.08							
Jul-27	9:0	.6	7.5	3.4	3000	30	134.0	0.04					134.0	0.01558	Wasted 150 ml ML
	22 :0	.5	7.5			30		0.02							
Jul-28	8:3	.7	7.3	3.3	3000	30	134.0	0.08					134.0		Wasted 150 ml ML
	17 :0	.3	7.8			30		0.04							
	23 :0	.4	7.7			30		0.08							
Jul-29	9:0	.3	7.5	3.6	3000	30	134.0	0.06					134.0	0.01695	Wasted 200 ml ML
	17 :0	.3	6.8			31		0.08							
	22 :0	.3	6.4			30		0.12							
Jul-30	9:0	.4	6.6	3.1	3000	30	134.0	0.1				7900/10200	134.0	0.01695	Wasted 100 ml ML
	17 :0	.3	6.4			30		0.06				R = 0.775			
	22 :0	.4	7.6			30		0.09							
Jul-31	8:3	.3	7.8	3.5	3000	30	134.0	0.05					134.1	0.01697	Wasted 150 ml ML
	17 :0	.5	7.7			30		0.04							
	23 :0	.6	7.4			30		0.08							
Aug-01	9:0	.5	7.2	2.9	3000	31	134.0	0.06					134.0	0.01695	Wasted 150 ml ML
	17 :0	.7	5.9			31		0.04							
	22 :0	.3	5.9			30		0.06							
Aug-02	9:0	.4	6.5	2.2	3000	30	156.0	0.05					134.0		Wasted 150 ml ML
	22 :0	.3	6.6			30		0.08							
Aug-03	9:0	.3	6.8	2.3	3000	30	156.0	0.03					156.0	0.02080	Wasted 150 ml ML
	22 :0	.5	6.4			31		0.09							
Aug-04	9:0	.3	6.5	2.8	3000	30	156.0	0.03				7500/10100	156.0	0.02080	Wasted 200 ml ML
	22 :0	.4	6.6			30		0.08				R = 0.742			
Aug-05	9:0	.3	6.8	2.6	3000	30	156.0	0.02					156.0	0.02080	Wasted 150 ml ML
	17 :0	.3	6.4			31		0.06							
	22 :0	.3	6.6			30		0.12							
Aug-06	8:3	.7	6.4	2.2	3000	30	156.0	0.02					156.0		Wasted 150 ml ML
	17 :0	.5	6.5			30		0.05							
	23 :0	.6	6.6			31		0.06							
Aug-07	9:0	.8	6.8	2.2	3000	30	144.0	0.02					156.0	0.01902	Wasted 225 ml ML
	17 :0	.6	6.4			31		0.07							
	22 :0	.7	6.5			30		0.05							
Aug-08	9:0	.8	6.7	2.3	3000	30	144.0	0.03				8200/10400	144.0	0.01755	Wasted 100 ml ML
	17 :0	.5	5.9			30		0.04				R = 0.788			
	22 :0	.6	6.5			30		0.03							
Aug-09	9:0	.5	6.6	2.2	3000	30	144.0	0.02					144.0	0.01756	Wasted 200 ml ML
	22 :0	.6	6.8			30		0.02							
Aug-10	9:0	.5	6.4	2.1	3000	30	144.0	0.03					144.0		Wasted 150 ml ML
	22 :0	.7	6.5			30		0.03							
Aug-11	8:3	.3	6.6	2.3	3000	31	144.0	0.02					144.0	0.02182	Wasted 150 ml ML
	17 :0	.5	6.8			30		0.03							
	22 :0	.6	6.4			30		0.06							

TABLE E1C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-n'tr/VSS	
		pH (Unit)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS VSS	Ratio	(mg/L)	(mg/mg	
Aug-12	9:00	7.5	6.6	2.2	3000	30	142.0	0.03				6600/8200	144.0	0.02182	Wasted 175 m/ML
	17:00	7.3	6.5			31		0.04				R = 0.804			
	22:00	7.4	6.6			30		0.07							
Aug-13	8:30	7.3	6.8	2.4	3000	30	142.0	0.03					142.0	0.02152	Wasted 150 ml ML
	17:00	7.4	6.6			30		0.03							
	22:00	7.3	6.8			30		0.02							
Aug-14	8:30	7.3	6.6	2.5	2000	30	94.7	0.03					142.0		No power since 4:20 pm
	16:00	7.3	2.8			28		0.06							No feed, no aeration
	22:00	7.2	0.8			25		0.03							Power restored at ~ 23:00
Aug-15	9:00	7.8	6.6	2.7	3000	29	142.0	0.05					94.6		Aerators partly replaced
	15:00	7.5	6.7	2.8		30		0.03							Feed line cleaned
	22:00	7.6	6.3			30		0.04							150 mg FeCl3 added
Aug-16	9:00	7.8	6.5	3.1	3000	30	142.0	0.06					142.0		5 g PAC added
	22:00	7.5	6.6			30		0.05							
Aug-17	9:00	7.6	6.8	3.2	3000	31	142.0	0.06					142.0	0.02058	150 mg FeCl3 added
	22:00	7.5	6.4			30		0.04							Wasted 175 m/ML
Aug-18	8:30	7.6	6.5	2.9	3000	30	142.0	0.06				6900/9100	142.0	0.02058	150 mg FeCl3 added
	17:00	7.5	6.6			30		0.04				R = 0.758			Wasted 150 ml ML
	22:00	7.5	7.1			29		0.05							
Aug-19	8:30	7.6	6.8	3.2	3000	30	200.0	0.06					142.0	0.02058	150 mg FeCl3 added
	17:00	7.5	6.6			30		0.05							Wasted 150 ml ML
	22:00	7.3	6.8			30		0.06							
Aug-20	9:00	7.4	6.9	3.1	3000	29	200.0	0.04					200.0		150 mg FeCl3 added
	17:00	7.3	6.6			30		0.03							Wasted 150 ml ML
	22:00	7.3	6.7			31		0.03							
Aug-21	8:30	7.3	6.8	3.2	3000	31	200.0	0.02					200.0	0.02837	150 mg FeCl3 added
	17:00	7.3	6.5			29		0.06							Wasted 150 ml ML
	22:00	7.3	6.6			30		0.04							
Aug-22	8:30	7.4	6.8	3.1	3000	30	200.0	0.06				7050/9100	200.0	0.02836	300 mg FeCl3 added
	17:00	7.3	6.4			30		0.05				R = 0.774			Wasted 150 ml ML
	22:00	7.3	6.5			30		0.08							
Aug-23	9:00	7.4	6.7	2.8	3000	29	200.0	0.03					200.0	0.02837	Wasted 100 ml ML
	22:00	7.3	6.9			30		0.09							300 mg FeCl3 added
Aug-24	8:30	7.4	6.5	2.7	3000	29	200.0	0.03					200.0		Wasted 150 ml ML
	22:00	7.3	6.6			29		0.08							300 mg FeCl3 added
Aug-25	9:00	7.5	6.8	2.9	3000	30	200.0	0.02					200.0		Wasted 200 ml ML
	17:00	7.6	6.4			30		0.06							
	22:00	7.5	6.5			30		0.04							
Aug-26	8:30	7.7	6.7	2.8	3000	30	200.0	0.02					200.0		300 mg FeCl3 added
	17:00	7.3	6.6			29		0.04							Wasted 100 ml ML
	22:00	7.4	6.7			30		0.05							
Aug-27	9:00	7.5	6.8	3.1	3000	31	200.0	0.06					200.0	0.02941	300 mg FeCl3 added
	17:00	7.5	6.8			29		0.09							Wasted 150 ml ML
	22:00	7.6	6.6			30		0.08							
Aug-28	8:30	7.5	6.8	3.3	3000	30	144.0	0.05				6800/8600	200.0	0.02941	300 mg FeCl3 added
	17:00	7.7	6.9			30		0.08				R = 0.790			Wasted 150 ml ML
	22:00	7.3	6.6			30		0.02							
Aug-29	9:00	7.4	6.7	3.2	3000	29	144.0	0.06					144.0	0.02113	300 mg FeCl3 added
	17:00	7.3	6.8			29		0.08							Wasted 225 ml ML
	22:00	7.3	6.8			30		0.02							
Aug-30	9:00	7.4	6.6	3.4	3000	30	144.0	0.06					144.0		450 mg FeCl3 added
	22:00	7.4	6.8			30		0.04							Wasted 100 ml ML
Aug-31	9:00	7.3	6.9	3.1	3000	30	144.0	0.02					144.0		450 mg FeCl3 added
	21:00	7.3	6.6			29		0.04							
Sep-01	9:00	7.4	6.7	3.3	3000	30	144.0	0.03					144.0	0.02149	450 mg FeCl3 added
	22:00	7.6	6.8			29		0.05							Wasted 100 ml ML
Sep-02	8:30	7.5	6.7	3.2	3000	29	164.0	0.02				6700/9200	144.0	0.02149	450 mg FeCl3 added
	17:00	7.7	6.7			30		0.05				R = 0.073			Wasted 150 ml ML
	22:00	7.3	6.6			30		0.08							

TABLE E1C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (Unit)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS VSS	Ratio	(mg/L)	(mg/mg)	
Sep-03	8:3[illegible]	7.4	6.7	3.3	3000	30	164.0	0.02					164.0	0.02448	600 mg FeCl3 added
	17:[illegible]	7.5	6.8			30		0.07							Wasted 100 ml ML
	22:[illegible]	7.5	6.8			30		0.06							
Sep-04	9:0[illegible]	7.6	6.6	3.1	3000	29	164.0	0.08					163.9	0.02827	600 mg FeCl3 added
	16:[illegible]	7.4	6.6			29		0.02							Wasted 150 ml ML
	22:[illegible]	7.3	6.8			30		0.06							
Sep-05	8:3[illegible]	7.4	6.6	3.2	3000	30	164.0	0.04				5800/8800	164.0	0.02828	600 mg FeCl3 added
	17:[illegible]	7.3	6.8			30		0.02				R = 0.66			Wasted 175 ml ML
	22:[illegible]	7.3	6.7			30		0.02							
Sep-06	9:0[illegible]	7.4	6.6	2.9	3000	29	164.0	0.06					164.0	0.02827	900 mg FeCl3 added
	22:[illegible]	7.3	6.7			30		0.04							Wasted 150 ml ML
Sep-07	9:0[illegible]	7.4	6.8	3.1	3000	29	164.0	0.02					164.0	0.02878	900 mg FeCl3 added
	22:[illegible]	7.3	6.7			29		0.04							
Sep-08	8:3[illegible]	7.3	6.7	3.2	3000	30	164.0	0.03				5700/8900	164.0	0.02877	900 mg FeCl3 added
	17:[illegible]	7.6	6.6			29		0.02				R = 0.64			Wasted 175 ml ML
	22:[illegible]	7.5	6.5			29		0.04							
Sep-09	8:3[illegible]	7.7	6.7	3.3	3000	30	164.0	0.05					164.0	0.02877	900 mg FeCl3 added
	17:[illegible]	7.3	6.6			29		0.06							Wasted 150 ml ML
	22:[illegible]	7.4	6.8			28		0.07							
Sep-10	9:0[illegible]	7.3	6.6	3.2	3000	28	164.0	0.08					164.0		900 mg FeCl3 added
	16:[illegible]	7.3	6.8			27		0.05							Wasted 150 ml ML
	22:[illegible]	7.4	6.7			27		0.08							
Sep-11	9:0[illegible]	7.4	6.6	3.3	3000	26	164.0	0.02					164.1	0.0278	*Temp. adjusted at 26 oC*
	16:[illegible]	7.3	6.6			25		0.04							900 mg FeCl3 added
	22:[illegible]	7.4	6.7			25		0.02							Wasted 150 ml ML
Sep-12	9:0[illegible]	7.3	6.6	3.2	3000	25	164.0	0.02				5900/9200	164.0	0.02780	900 mg FeCl3 added
	17:[illegible]	7.3	6.7			25		0.04				R = 0.641			Wasted 100 ml ML
	22:[illegible]	7.4	6.6			25		0.02							
Sep-13	9:0[illegible]	7.3	6.7	3.1	3000	26	164.0	0.02					164.0	0.02780	Temp. adjusted at 24 oC
	22:[illegible]	7.4	6.8			24		0.06							600 mg FeCl3 added
Sep-14	8:0[illegible]	7.3	6.7	3.2	3000	24	164.0	0.04					164.0		Wasted 100 ml ML
	22:[illegible]	7.4	6.7			23		0.02							
Sep-15	8:3[illegible]	7.3	6.6	3.2	3000	22	164.0	0.04					164.0		2 L of ML replaced with water
	17:[illegible]	7.4	6.8			21		0.02							600 mg FeCl3 added
	22:[illegible]	7.3	6.6			22		0.04							Temp. adjusted at 21 oC
Sep-16	9:0[illegible]	7.4	6.6	3.2	3000	21	164.0	0.02					164.0		1L of ML replaced with water
	17:[illegible]	7.3	6.8			21		0.04							600 mg FeCl3 added
	22:[illegible]	7.3	6.6			21		0.02							
Sep-17	9:0[illegible]	7.6	6.8	2.9	3000	20	164.0	0.02					164.0		1L ML replaced with water
	16:[illegible]	7.5	6.7			21		0.04							600 mg FeCl3 added
	22:[illegible]	7.7	6.6			21		0.02							
Sep-18	9:0[illegible]	7.3	6.7	3.1	3000	20	178.0	0.08					163.9	0.04204	
	17:[illegible]	7.3	6.6			20		0.05							
	22:[illegible]	7.4	6.8			20		0.06							
Sep-19	9:0[illegible]	7.3	6.6	2.9	3000	20	178.0	0.07				3900/5900	178.0	0.04564	600 mg FeCl3 added
	17:[illegible]	7.3	6.8			20		0.08				R = 0.661			Wasted 150 ml ML
	22:[illegible]	7.4	6.7			20		0.05							
Sep-20	8:3[illegible]	7.3	6.6	3.3	3000	21	178.0	0.08					178.0	0.04564	Wasted 100 ml ML
	22:[illegible]	7.3	6.8			21		0.02							600 mg FeCl3 added
Sep-21	8:3[illegible]	7.4	6.7	3.1	3000	20	178.0	0.04					178.0	0.04685	600 mg FeCl3 added
	22:[illegible]	7.3	6.6			20		0.02							
Sep-22	9:0[illegible]	7.5	6.8	3.2	3000	21	178.0	0.03				3800/5200	178.0	0.04684	600 mg FeCl3 added
	17:[illegible]	7.4	6.7			22		0.04				R = 0.73			**Upset induced by turning off air with 2 feed cycles**

TABLE E1C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR1

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH	T (Un)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Details for Sep 23 - 11 Sep-25 in Upset Summary Table 1																	
Sep-25	9:0	7.5	6.6	3.3		3000	29	178.0	0.09						178.0		600 mg FeCl3 added
	17:0	7.7	6.7				29		0.06								Wasted 150 ml ML
	22:0	7.3	6.8				27		0.07								
Sep-26	9:0	7.3	6.7	3.1		3000	25	178.0	0.05						178.0		600 mg FeCl3 added
	22:0	7.4	6.7				25		0.06								
Sep-27	9:0	7.5	6.6	3.2		3000	23	178.0	0.05						178.0		600 mg FeCl3 added
	22:0	7.7	6.7				23		0.07								Wasted 150 ml ML
Sep-28	9:0	7.3	6.8	3.1		3000	23	178.0	0.04						178.0	0.04045	600 mg FeCl3 added
	22:0	7.3	6.7				22		0.06								
Sep-29	9:0	7.4	6.7	3.1		3000	23	178.0	0.05					4400/6300	178.0	0.04045	600 mg FeCl3 added
	17:0	7.3	6.6											R = 0.698			**Upset induced by NaOH addition to pH 11.5 with one feed cycle**
Details for Sep 29 - 11 Oct-3 in Upset Summary Table 2																	
Oct-03	9:0	7.6	6.8	2.9		3000	30	178.0	0.03						178.0		600 mg FeCl3 added
	17:0	7.3	6.7				30		0.06								Wasted 150 ml ML
	22:0	7.6	6.6				29		0.04								
Oct-04	9:0	7.5	6.6	3.1		3000	30	178.0	0.03						178.0	0.04045	600 mg FeCl3 added
	22:0	7.6	6.6				30		0.04								Wasted 150 ml ML
Oct-05	9:0	7.5	6.7	2.9		3000	29	178.0	0.05					4200/6400	178.0	0.04045	600 mg FeCl3 added
	22:0	7.3	6.7				30		0.06					R = 0.656			Wasted 100 ml ML
Oct-06	8:3	7.3	6.8	3			30		0.05								600 mg FeCl3 added
	17:0	7.4	6.7			3500	30	207.7	0.03						207	0.04705	**Feed extended to 4 days HRT**
	22:0	7.3	6.7				30		0.03								New timer installed
Oct-07	9:0	7.3	6.6	2.8		3750	30	222.5	0.04						222		600 mg FeCl3 added
	17:0	7.4	6.8				30		0.05								Wasted 100 ml ML
	22:0	7.3	6.6				30		0.03								**Feed extended to 3.5 days HRT**
Oct-08	8:3	7.4	6.8	2.6		4000	30	237.3	0.06						237		600 mg FeCl3 added
	17:0	7.3	6.6				30		0.05								Wasted 200 ml ML
	22:0	7.6	6.8				30		0.03								
Oct-09	8:3	7.5	6.7	2.7		4500	30	267.0	0.04						267	0.06512	600 mg FeCl3 added
	17:0	7.6	6.6				30		0.05								Wasted 200 ml ML
	22:0	7.5	6.6				30		0.03								
Oct-10	8:3	7.8	6.6	2.9		5000	29	296.7	0.03					4100/6300	297	0.07244	**Feed extended to 3 days HRT**
	17:0	7.7	6.8				28		0.04					R = 0.650			Temp set up at 28oC
	22:0	7.8	6.7				28		0.05								600 mg FeCl3 added
Oct-11	9:0	7.9	6.6	2.6		5000	26	296.7	0.03						297	0.07244	Temp set up at 25 oC
	22:0	7.6	6.8				25		0.03								600 mg FeCl3 added
Oct-12	9:0	7.7	6.7	2.8		5000	24	296.7	0.04						297		Temp set up at 23 oC
	22:0	7.8	6.6				23		0.05								600 mg FeCl3 added
Oct-13	9:0	7.8	6.8	2.7		5000	23	296.7	0.03						297	0.08253	600 mg FeCl3 added
	22:0	7.9	6.7				23		0.06								Wasted 200 ml ML
Oct-14	8:3	7.6	6.6	2.8		5000	21	296.7	0.05					3600/5500	297	0.08253	600 mg FeCl3 added
	17:0	7.8	6.6				20		0.04					R = 0.650			**Heater removed**
	22:0	7.5	6.6				20		0.08								Wasted 200 ml ML
Oct-15	8:3	7.8	6.9	3.2		5000	20	296.7	0.03						297	0.10241	600 mg FeCl3 added
	17:0	7.9	7.2				19		0.11								Wasted 250 ml ML
	22:0	7.8	7.5				20		0.09								
Oct-16	9:0	7.9	7.8	3.3		5000	19	296.7	0.04					2900/4600	297	0.10241	600 mg FeCl3 added
	17:0	7.8	7.6				19		0.03					R = 0.63			Wasted 250 ml ML
	22:0	7.9	7.2				19		0.04								
Oct-17	8:3	7.9	7.4	3.5		1800	19	106.8	0.02								**Last feed to the system**
	16:0	7.8	7.1				19		0.06								200 mg FeCl3 added

TABLE E2A

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION - CLAIRTON SLUDGE
SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date		Operational Parameters						TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS	Comments
		pH (St Un)	DO (mgO2/l)	DO(5 min)	Feed (ml/day) Water	Feed (ml/day) Groundwater	Temperature (oC)		COD	NH3-N	NO3-N	TSS	VSS				
Feb-09	9:00	7.3	6.4	2.3			26	0.0		3.5							
		7.6	6.8	2.4			26			3.1							no feed
Feb-10	9:00	7.8	6.6	2.3			26	0.0		2.7				14300/21200	17.3		
	18:00	7.4	6.8	2.2			26			1.6				R =0.66			
Feb-11	9:00	7.3	6.2	2.7	2700	300	26	16.2		0.1					21.4		1.0 g Na2CO3
	18:00	7.3	6.8	2.6			26			0.15							
Feb-12	9:00	7.9	6.4	1.9	2600	400	26	21.4		0.2					26.6		2 ml buffer
	18:00	7.3	6.2	1.1			26			0.3							
Feb-13	9:00	7.4	6.2	2.1	2500	500	26	26.7		0.4					32.2		0.6 g Na2CO3
	18:00	7.2	6.8	2.5			26			0.2							
Feb-14	9:00	7.8	6.6	2.2	2400	600	26	32.0		0.15				15800/22800	37.3		0.9 g Na2CO3
	17:30	8	6.8	2.4			26			0.2				R = 0.692			
Feb-15	9:00	7.6	6.4	2.3	2300	700	26	37.3	180	0.35	110				42.7		1.0 g Na2CO3, flocculant
	18:00	7.5	6.5	2.2			26			0.3							
Feb-16	9:00	7.6	6.6	2.1	2200	800	26	42.7	100	0.4	110				48.2		1.0 g Na2CO3, flocculant
	18:00	7.2	6.9	2.5			28			0.25							
Feb-17	9:00	7.3	6.2	2.1	2100	900	28	48.0	150	0.2	112				53.3		2.0 g Na2CO3, no feed
	17:30	7.2	6.8	2.3			28			0.15							
Feb-18	9:00	7.6	6.6	2.2	2000	1000	27	53.3	260	0.5	115				-0.3		2.0 g Na2CO3, no feed
	18:00	6.4	6.5	2.4			27			0.8							
Feb-19	9:00	6.5	6.4	2.1	3000	0	26	0	220	8.9	110			15200/21600			5.0 g Na2CO3, no feed
	18:00	6.6	6.8	2.3			28			7.3				R = 0.703			
Feb-20	9:00	7.8	6.6	2.2	3000	0	28	0	240	7.6	96						5.0 g Na2CO3, no feed
	18:00	7.6	6.6	2.2			28			9.2							
Feb-21	9:00	7.4	6.2	2.2	3000	0	28	0	190	19.1	86	98	60				2.0 g Na2CO3, no feed, 2 ml buffer
	18:00	8.2	6.5	2.4			28			17.1							
Feb-22	9:00	7.6	6.8	2.3	3000	0	28	0	160	21	75	240	190				1.0 g Na2CO3, no feed
	18:00	7.5	6.6	2.2			28			12.6							
Feb-23	9:00	7.8	6.4	1.9	3000	0	26	0	170	17	73	220	180				1.0 g Na2CO3, no feed
	18:00	6.9	6.6	2.2			26			16.2							
Feb-24	9:30	7.2	6.6	2.2	3000	0	26	0	160	17.1	68	170	64	16200/22700			2.0 ml buffer, Anionic flucculant
	17:30	7.8	6.2	2.7			26			9.8				R = 0.713			
Feb-25	9:00	7.6	6.4	2.2	3000	0	26	0	110	10.5	56	170	59				1.0 ml buffer, 200 ml AS R # 3
	18:00	7.4	6.8	2.3			26			11.9							
Feb-26	9:00	7.6	6.2	1.9	3000	0	26	0	140	12.6	50	25	18				1.0 ml buffer, 300 ml AS R # 3
	17:30	7.3	6.5	2.4			26			10.6							
Feb-27	9:00	7.2	6.6	2.1	3000	0	26	0	130	10.2	35	11	9				1.0 ml buffer, 500 ml AS R # 3
	18:00	7.1	6.2	2.6			26			9.6							
Feb-28	9:00	7.9	6.4	2.2	3000	0	26	0	150	9.2	32	18	12				1.0 ml buffer, 500 ml AS R # 3
	18:00	7.3	6.5	2.4			27			9.6							
Mar-01	9:00	7.8	6.2	2.2	3000	0	27	0	120	8.6	29	28	24				1.0 ml buffer, 500 ml AS R # 3
	17:30	7.5	6.7	2.6			26			8.3							
Mar-02	9:00	7.6	6.4	1.8	3000	0	26	0	110	5	28	22	22				1.0 ml buffer, 500 ml AS R # 3
	18:00	7.4	6.9	2.5			26			5.2							
Mar-03	9:00	7.7	6.7	2.6	3000	0	26	0	98	5	26	29	25	12300/21300			1.0 ml buffer, 500 ml AS R # 3
	16:30	7.3	6.5	1.9			26			2.8				R = 0.624			
Mar-04	9:00	7.4	6.3	2.7	2800	200	26	9.6	120	0.16	36	46	38		14.4	0.00108	New Feed, 1 ml buffer
	17:30	7.6	6.8	2.3			27			0.2							
Mar-05	8:30	8.2	6.6	2.2	2700	300	27	14.4	98	0.3	38	59	54		14.4	0.00108	1.0 ml buffer
	18:00	7.9	6.6	2.2			28			0.3							
Mar-06	9:00	7.9	6.2	2.2	2700	300	28	14.4	92	0.22	40	64	60		14.3	0.00107	1.0 ml buffer
	17:00	8	6.5	2.4			27			0.34							
Mar-07	9:30	8.1	6.8	2.3	2700	300	27	14.4	78	0.13	45	37	26		14.4	0.00108	1.0 ml buffer
	18:00	7.8	6.6	2.2			27			0.16							
Mar-08	9:00	7.8	6.4	1.8	2700	300	27	14.4	84	0.52	49	62	53	12700/19700	14.5	0.00114	100 ml ML wasted
	17:30	7.9	6.6	2.2			27			0.4				R = 0.64			1.0 ml buffer

TABLE E2A

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION - CLAIRTON SLUDGE
SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date		Operational Parameters							Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS	Comments
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml/day)		Temperature (oC)	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS				
					Water	Groundwater											
Mar-09	8:30	7.6	6.6	2.2	2700	300	28	14.4	76	0.35	54	38	32		14.5	0.00114	
	17:30	7.8	6.2	2.7			28			0.22							1.0 ml buffer
Mar-10	9:00	7.7	5.4	2.2	2700	300	27	14.4	82	0.12	58	32	28		14.3	0.00113	
	18:00	7.8	6.8	2.5			28			0.2							additional heater & aerator
Mar-11	9:00	8.1	6.2	1.9	2700	300	27	14.4	34	0.11	63	39	36		14.3		pH controllers calibrated
	17:30	8	6.5	2.4			27			0.18							
Mar-12	9:00	7.7	6.9	2.2	1600	400	28	14.4	59	0.15	68	43	38		14.3		
	18:00	7.6	6.9	2.2			27			0.22							
Mar-13	9:00	7.6	6.7	2.2	1600	400	27	14.4	57	0.08	72	35	24		19.1		1.0 ml buffer
	18:00	7.5	6.5	2.2			27			0.18							
Mar-14	9:00	7.6	6.3	2.4	1550	450	27	19.2	62	0.36	79	46	39		24.2		
	18:00	7.5	6.8	2.3			27			0.16							
Mar-15	9:00	7.6	6.9	2.2	1500	500	27	24.0	72	0.38	83	48	39		24.2		
	18:00	7.6	6.6	2.8			27			0.2							
Mar-16	9:00	7.8	6.2	2.2	1500	500	27	24.0	88	0.46	87	38	32		24.3		
	18:00	7.6	6.4	2.6			27			0.2							
Mar-17	9:00	7.7	6	2.4	1500	500	27	24.0	90	0.38	92	35	27	10700/16000	33.7	0.00315	100 ml ML wasted
	17:30	7.7	6.3	–			29			0.27				R = 0.668			
Mar-18	9:00	7.6	6.8	2.9	1300	700	29	33.6	87	0.17	110	33	22		38.2	0.00357	
	18:00	7.6	6.4	–			28			0.39							
	23:00	7.7	6.6	–			28			0.59							
Mar-19	9:00	7.6	7.2	3.2	1200	800	29	38.4	82	0.15	130	31	22		47.7	0.00446	100 ml ML wasted
	17:00	7.6	6.6	–			28			0.41							
	23:00	7.5	6.5	–			28			0.6							
Mar-20	9:00	7.5	6.4	2.3	1000	1000	28	48.0	62	0.17	137	24	16		52.3	0.00489	100 ml ML wasted
	17:00	7.6	6.4	–			28			0.64							
	23:00	7.6	6.3	–			28			0.7							
Mar-21	9:00	7.7	6.9	2.2	900	1100	29	52.8	73	0.16	160	30	28		62.1		100 ml ML wasted
	17:00	7.6	6.8	–			29			0.51							
	23:00	7.5	6.2	–			29			0.52							
Mar-22	9:00	7.5	6.4	2.3	700	1300	29	62.4		0.26					66.9		100 ml ML wasted
	16:30	7.5	6.4	–			29			0.58							
	23:00	7.6	6.7	–			28			0.53							
Mar-23	9:00	7.5	6.3	2.4	600	1400	29	67.2		0.17					76.3	0.00830	100 ml ML wasted
	16:00	7.6	6.2	–			28			0.43							
	23:00	7.6	6.5	–			28			0.48							
Mar-24	9:00	7.6	6.3	2.5	400	1600	28	76.6	68	0.18	210	11	7	9200/14700	81.2	0.00882	
	17:00	7.5	6.6				29			0.63				R = 0.626			
	23:00	7.6	6.7				29			0.2							
Mar-25	9:00	7.6	6.8	2.8	300	1700	29	81.6		0.16					86.6	0.00941	
	16:30	7.5	7.3				28			0.19							
	23:00	7.7	6.8				29			0.3							
Mar-26	9:00	7.6	6.7	2.7	200	1800	29	86.6		0.22					85.3	0.00927	
	17:00	7.4	6.8				28			1.5							
	23:00	7.5	6.2				28			5.5							Feed disconnected
Mar-27	9:00	7.5	6.8	2.6	200	1800	29	86.6	70	0.17	230	9	8		90.7		
	16:30	7.6	6.6				29			0.76							
	23:00	7.5	6.8				29			0.87							
Mar-28	9:00	7.5	7.4	2.9	100	1900	28	91.3		0.18					90.6		
	16:30	7.6	7.3				29			0.92							
	23:00	7.6	7.1				29			0.86							
Mar-29	9:00	7.5	6.9	2.8	100	1900	29	91.3		0.16					95.5	0.01137	
	16:30	7.5	6.8				28			0.68							
	23:00	7.6	6.4				29			0.72							

TABLE E2A

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION - CLAIRTON SLUDGE
SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date		Operational Parameters							Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nit:/VSS	Comments
		pH (St Un)	DO (mgO2/L)	DOC 5 min	Feed (mL/day) Water	Feed (mL/day) Groundwater	Temperature (oC)	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS				
Mar-30	9:00	7.4	5.9	2.7	0	2000	30	96.0		0.18					95.5	0.01137	
	16:30	7.5	5.7				30			0.68							
	23:00	7.5	7.2				29			0.66							
Mar-31	9:30	7.6	5.9	2.8	0	2000	29	96.0	76	0.16	270	12	10	8400/13500	94.7	0.01127	
	17:00	7.4	5.6				28			1.5				R = 0.622			
	23:00	7.5	5.8				29			0.8							
Apr-01	9:00	7.5	5.8	2.5	0	2000	29	96.0		0.2					95.8	0.01140	
	16:00	7.5	5.3				30			0.43							
	23:00	7.6	5.9				29			0.56							
Apr-02	9:00	7.4	5.8	2.8	0	2000	29	96.0		0.14					95.9	0.01142	
	17:00	7.6	5.5				29			0.22							
	23:00	7.5	5.6				29			0.62							
Apr-03	9:00	7.4	5.4	3.1	0	2000	28	96.0		0.21					95.9		
	17:00	7.4	5.7				29			0.32							
	23:00	7.3	5.4				29			0.46							
Apr-04	9:00	7.4	5.3	2.9	0	2000	30	96.0		0.22					94.4		
	16:30	7.5	5.4				28			1.8							
	23:00	7.5	5.9				29			2.1							
Apr-05	9:00	7.5	5.7	2.8	0	2000	29	96.0		0.15					94.9	0.01054	
	17:00	7.5	7.2				28			1.3							
	23:00	7.5	6.9				29			1.2							
Apr-06	9:00	7.5	5.6	2.6	0	2000	29	96.0		0.17					95.2	0.01058	15 g PAC added
	17:00	7.6	5.8				30			0.98							
	23:00	7.5	5.8				30			1.7							
Apr-07	9:00	7.5	6.9	2.2	0	2000	30	96.0		0.15				9300/13900	95.9	0.01066	15 g PAC added
	16:30	7.5	6.4				29			0.24				R = 0.647			
	23:00	7.4	6.9				29			0.62							
Apr-08	9:00	7.5	6.7	2.4	0	2000	28	96.0		0.12					93.4	0.01038	15 g PAC added
	17:00	7.4	6.7				29			2.7							
	23:00	7.6	6.4				29			1.6							
Apr-09	9:00	7.5	6.3	2.6	0	2000	29	96.0		0.14					96.0	0.01067	15 g PAC added
	17:00	7.4	6.4				28			0.11							
	23:00	7.4	6.9				29			0.65							
Apr-10	9:00	7.5	6.7	2.8	0	2000	29	96.0		0.16				9200/14500	96.0	0.01043	15 g PAC added
	17:00	7.5	7.8				28			2.8				R = 0.634			
	23:00	7.4	6.9				28			1.1							

TABLE E2B

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	
		pH (S. Un)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS			
Apr-11	9:00	7.3	7.4	2.9	2000	28	101.3	0.14						#REF!	#REF!	< 10 g PAC
	16:30	7.4	7.2			29		1.3								
	23:00	7.4	7.4			28		0.68								
Apr-12	8:30	7.4	7.2	2.8	2000	29	101.3	0.05						101.4	0.00930	
	17:00	7.3	7.6			28		0.82								
	23:00	7.3	6.9			29		0.63								
Apr-13	9:00	7.4	7.4	2.8	2000	28	101.3	0.14					10900/16500	101.2	0.00929	100 mL RAS wasted
	17:30	7.3	7.4			28		0.52					R = 0.660			
	23:00	7.4	7.2			28		0.43								
Apr-14	9:00	7.4	7.6	2.6	2000	28	101.3	0.12						101.4	0.00930	100 mL RAS wasted
	17:00	7.4	7.4			28		0.56								
	23:00	7.3	7.2			28		0.44								
Apr-15	9:00	7.4	7.3	2.9	2000	29	101.3	0.14						101.3		
	17:30	7.3	7.6			28		0.18								
	23:00	7.3	7.4			29		0.68								

TABLE E2B

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	
		pH (S. Unit)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS				
Apr-16	9:00	7.4	7.2	2.5	2000	28	101.3		0.12					101.3	0.01045	
	17:00	7.4	7.3			29			2.8							
	23:00	7.4	7.6			28			1.2							
Apr-17	9:30	7.4	7.4	2.4	2000	29	101.3		0.13				9700/14800	101.3	0.01045	
	16:30	7.4	7.2			28			1.6				R = 0.655			
	23:00	7.5	7.3			29			2.1							
Apr-18	9:30	7.4	7.6	2.8	2000	28	101.3		0.12					101.3	0.01045	
	17:00	7.4	7.4			28			0.15							
	23:00	7.4	7.2			28			0.36							
Apr-19	9:00	7.4	7.4	2.4	2000	29	101.3		0.1					101.4		
	16:00	7.4	7.2			28			0.18							
	23:00	7.4	7.3			29			0.29							
Apr-20	8:30	7.4	7.6	2.5	2000	28	101.3		0.12					101.3	0.01078	
	16:30	7.5	7.4			29			0.28							
	23:00	7.4	6.8			28			0.32							
Apr-21	8:30	7.5	7.1	2.1	2000	29	105.3	48	0.09	450	16	11	9400/14200	101.4	0.01078	
	16:00	7.4	5.8			29			0.14				R = 0.662			
	23:00	7.4	6.2			28			0.32							
Apr-22	9:00	7.4	6.6	1.9	2000	28	105.3		0.15					105.3	0.01120	
	16:00	7.4	6.2			28			0.18							
	23:00	7.4	6.2			29			0.28							
Apr-23	8:30	7.4	6.6	1.6	2000	28	105.3		0.13					105.4	0.01145	
	16:30	7.4	6.5			29			0.15							
	23:00	7.4	6.3			28			0.22							
Apr-24	8:30	7.4	5.9	1.9	2000	29	105.3		0.14				9200/14100	105.3	0.01145	
	16:30	7.5	5.8			28			0.68				R = 0.652			
	23:00	7.5	5.6			29			0.42							
Apr-25	9:00	7.4	5.4	2.1	2000	28	105.3		0.24					105.2	0.01144	Additional air-pump
	16:30	7.4	6.3			28			1.5							
	23:00	7.4	6.2			28			0.72							
Apr-26	8:30	7.5	6.6	2.5	2000	28	105.3		0.14					105.4	0.01146	
	18:00	7.4	6.5			29			0.64							
Apr-27	9:30	7.5	6.3	2.2	2000	28	105.3		0.11					105.4		
	18:00	7.4	6.2			28			0.68							
Apr-28	8:30	7.4	5.9	2.1	2000	28	105.3		0.14					105.3		
	16:30	7.5	6.1			28			1.1							
	23:00	7.4	6.4			29			0.82							
Apr-29	9:00	7.4	5.7	1.9	2000	29	105.3	36	0.09	460	9	6		105.4		Air flow adjustment
	17:00	7.5	6.2			28			0.56							
	23:00	7.4	6.6			29			0.32							

TABLE E2B

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitr/VSS (mg/mg)	
		pH (S: U:	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS				
Apr-30	8:30	7.	6.5	2.3	2000	28	105.3		0.08					105.3	0.01225	
	18:00	7.	6.3			29			0.16							
	23:00	7.	5.9			28			0.29							
May-01	8:30	7.	5.8	2.2	2000	28	105.3		0.09				8600/12800	105.3	0.01225	
	16:30	7.	5.6			28			0.16				R = 0.671			
	23:00	7.	5.4			28			0.28							
May-02	8:30	7.	6.2	2.4	2000	29	105.3		0.12					105.3	0.01224	
	18:00	7.	6.6			28			0.22							
	23:00	7.	6.5			28			0.29							
May-03	9:00	7.	6.3	1.9	2000	29	105.3		0.09					105.4		
	17:00	7.	5.9			29			0.18							
May-04	9:00	7.	5.8	2.2	2000	29	105.3		0.14					105.3	0.01253	
	17:00	7	5.6			30			0.1							Air flow adjustment
	23:00	7.	5.4			29			0.26							
May-05	9:00	7	6.3	1.8	2000	30	105.3		0.17				8400/12500	105.3	0.01254	
	17:00	7	6.2			30			0.12				R = 0.672			
	23:00	7	6.6			29			0.23							
May-06	8:30	7	6.5	2.3	2000	29	105.3	34	0.08	490	10	7		105.4	0.01255	
	16:30	7	6.2			28			0.11							
	23:00	7	5.9			29			0.32							
May-07	9:00	7	6.3	2.1	2000	29	105.3		0.12					105.3		
	17:00	7	6.1			29			0.44							
	23:00	7	5.8			30			0.29							
May-08	9:00	7	6.4	2.2	2000	29	104.0		0.1					105.4		
	16:30	7	6.2			29			0.28							
	23:00	7	6.1			29			0.36							
May-09	9:00	7	5.8	1.9	2000	28	104.0		0.16					103.9		
	17:00	7	5.9			29			0.24							
	23:00	7	5.7			29			0.31							
May-10	10:00	7	5.8	1.8	2000	29	104.0		0.22					103.9		
	23:00	7	5.6			29			0.29							
May-11	10:30	7	5.5	1.6	2000	29	104.0		0.17					104.1	0.01317	
	22:30	7	5.8			29			0.48							
May-12	8:30	7	5.3	1.5	2000	28	104.0		0.25				7900/11400	103.9	0.01315	
	17:00	7	5.2			29			0.62				R = 0.692			
	23:00	7	4.9			29			0.38							
May-13	9:00	7	4.6	1.3	2000	30	104.0		0.18					104.1	0.01317	New diffusers and pump
	17:00	7	6.3			29			1.2							
	23:00	7	5.8			29			0.67							

TABLE E2B

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	*Operational Parameters*					*TKN load (mg/L)*	*Effluent Analytical Data (mg/L)*				*MLVSS/MLTSS Ratio*	*NH3-N nitrif (mg/L)*	*NH3-nitr/VSS (mg/mg)*	
		pH (S: Un)	*DO (mgO2/L)*	*DO (15 min)*	*Feed (ml)*	*Temp*		*COD*	*NH3-N*	*NO3-N*	*TSS* *VSS*				
May-14	9:00	7.	6.4	2.2	2000	30	104.0	0.46					103.7	0.01365	pH probed stacked/washed
	16:00	7.	5.7			29		1.3							additional soda ash pumped
	23:00	7.	5.9			29		0.68							pH adjusted with H3PO4
May-15	8:30	7.	6.2	2.1	2000	29	104.0	0.3				7600/10600	104.2	0.01371	
	16:30	7.	6.1			29		0.16				R = 0.716			
	23:00	7.	5.8			29		0.32							
May-16	8:30	7	6.4	2.6	2000	30	104.0	0.18					104.1	0.01370	
	16:30	7.	6.2			30		0.33							
	23:00	7.	6.1			29		0.29							
May-17	10:00	7.	5.8	2.7	2000	29	77.3	0.12					104.1		
	23:00	7.	6.1			29		0.28							

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date		Operational Parameters:					TKN load (mg/L)	Effluent Analytical Data (mg/L)					MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (St Un)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
May-18	11	7.3	5.8	1.9	2000	29	77.3		0.12							
	23	7.4	6.4			30			0.31							
May-19	5	7.4	6.2	2.8	2000	29	77.3		0.08					77.4	0.01046	
	16	7.3	6.1			29			0.22							
	23	7.3	5.8			29			0.29							
May-20	5	7.4	5.9	2.2	2000	29	77.3		0.09				7400/9900	77.3	0.01045	
	16	7.4	6.2			29			0.38				R = 0.747			
	22	7.4	5.7			29			0.42							
May-21	9	7.5	6.3	2.5	2000	29	77.3	78	0.21	540	9	8		77.2	0.01043	
	17	7.5	6.1			30			0.38							
	22	7.4	5.7			29			0.34							
May-22	9	7.5	5.9	2.1	2000	30	77.3		0.04					77.5	0.01092	
	17	7.3	5.8			29			0.68							
	22	7.3	6.4			29			0.56							
May-23	9	7.3	5.7	2.4	2000	29	77.3		0.09				7100/9500	77.3	0.01088	Diffusers replaced
	17	7.4	5.9			29			1.1				R = 0.747			
	22	7.3	5.8			29			0.78							
May-24	10	7.3	6.4	2.8	2000	29	77.3		0.16					77.3	0.01088	Air flow adjusted
	22	7.3	5.7			29			0.32							
May-25	9	7.3	5.9	2.2	2000	29	77.3		0.16					77.3		
	23	7.3	5.8			29			0.28							
May-26	8	7.4	6.4	2.3	2000	29	77.3		0.13					77.4	0.01105	
	17	7.3	5.7			29			0.71							
	22	7.3	5.9			29			0.64							
May-27	8	7.4	6.2	2.6	2000	29	77.3		0.1				7000/9500	77.4	0.01105	Feed changed to 4 cycles/day
	18	7.5	5.9			30			0.22				R = 0.736			
	23	7.5	5.8			29			0.29							
May-28	9	7.4	6.4	2.9	2000	29	77.3		0.14					77.3	0.01104	
	17	7.5	5.7			30			0.2							
	23	7.3	5.9			31			0.16							
May-29	8	7.4	5.8	2.4	2100	33	81.2		0.14					77.3		Feed changed to 3.6 cycles.
	16	7.4	5.7			29			0.18							One heater broken, removed
	23	7.3	5.9			29			0.26							
May-30	8	7.3	5.8	2.2	2100	29	81.2		0.21				6900/9900	81.1	0.01176	
	17	7.3	6.4			29			0.35				R = 0.697			
	23	7.3	5.7			29			0.19							
May-31	10	7.3	5.9	2.1	2100	30	81.2		2.8					78.6	0.01139	
	23	7.4	5.8			29			0.16							
Jun-01	9	7.3	6.4	2.7	2100	29	81.2		0.08					83.9	0.01216	
	23	7.3	5.7			30			0.21							
Jun-02	9	7.4	5.9	2.3	2100	30	81.2		0.11					81.2	0.01211	Feed changed to 3 cycles/day
	18	7.5	6.2			29			0.41							
	23	7.4	6.2			29			0.32							
Jun-03	9	7.5	5.9	2.5	2400	29	92.8		0.1				6700/9500	81.2	0.01212	
	18	7.3	6.2			30			0.08				R = 0.726			
	23	7.4	6.3			29			0.16							
Jun-04	8	7.4	6.2	2.7	2400	29	92.8		0.08					92.8	0.01385	
	17	7.5	5.9			29			0.06							
	23	7.4	6.1			29			0.12							
Jun-05	9	7.4	6.2	2.2	2400	28	92.8		0.09					92.8	0.01385	
	17	7.3	5.7			29			2.9							
	23	7.3	5.9			29			0.22							

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (St Un)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Jun-06	5:3	7.4	5.8	1.5	2700	29	104.4	0.12						92.8		
	17:0	7.3	6.4			28		5.9								
	23:0	7.3	5.7			29		0.28								
Jun-07	10:0	7.4	5.9	1.6	2800	29	108.3	0.68						103.8		
	23:0	7.5	5.8			28		0.32								
Jun-08	9:0	7.4	6.4	1.9	2800	29	108.3	0.08						108.9	0.01512	
	23:0	7.4	5.7			29		0.26								
Jun-09	8:3	7.3	5.9	1.7	3000	29	116.0	0.12					7200/10600	108.2	0.01503	
	17:0	7.3	5.7			28		10.5					R = 0.679			
	23:0	7.4	5.9			29		22.5								
Jun-10	8:3	7.5	5.7	1.8	2800	28	108.3	2.8						113.3	0.01574	
	10:0	7.5	6.2	3.6		29		32.6								Feed discont, 2 L ML taken to R3
	17:0	7.4	5.9			29		10.5								Added: 1L ML from R1 and 1L water
	22:0	7.5	5.8			29		2.2								
Jun-11	8:3	7.4	6.2	2.4	3000	28	116.0	0.13						110.9		
	5:3	7.5	4.6			29		11.3								
	23:0	7.4	5.9			29		0.9								
Jun-12	8:3	7.5	4.9	1.5	3000	28	116.0	0.07						116.1	0.01758	
	17:0	7.4	5.7			29		7.9								
	22:3	7.5	5.9			28		0.09								
Jun-13	9:0	7.4	5.8	1.6	3000	29	116.0	0.07					6600/9200	116.0	0.01758	
	17:0	7.5	5.7			29		4.8					R = 0.717			
	23:0	7.3	5.9			29		0.08								
Jun-14	8:3	7.4	5.8	1.8	3000	28	116.0	0.1						116.0	0.01757	
	23:0	7.4	5.7			29		0.09								
Jun-15	9:0	7.5	5.9	1.6	3000	28	116.0	0.07						116.0	0.01758	
	22:3	7.4	5.8			29		0.12								
Jun-16	8:3	7.4	5.7	1.7	3000	28	116.0	0.06						116.0		
	17:0	7.3	5.9			29		5.1								
	23:0	7.3	5.8			29		0.11								
Jun-17	8:3	7.4	6.1	1.9	3000	29	98.0	0.05						116.0	0.01671	250 ml ML wasted for analyses
	17:0	7.3	5.7			28		5.4								Air flow adjusted
	22:30	7.3	5.9			29		0.08								
Jun-18	8:3	7.4	5.8	1.4	3000	28	98.0	0.07					6200/9100	98.0	0.01580	
	17:0	7.4	6.2			29		0.12					R = 0.681			
	22:0	7.5	6.1			29		0.09								
Jun-19	8:3	7.3	6.2	2.1	3000	29	98.0	0.04						98.0	0.01581	
	17:0	7.4	5.9			28		0.07								
	22:0	7.4	5.8			29		0.08								
Jun-20	8:3	7.4	5.7	1.6	3000	28	98.0	0.05						98.0	0.01580	250 ml ML wasted for analyses
	17:0	7.5	5.9			29		6.5								
	23:0	7.3	5.9			29		0.07								
Jun-21	10:0	7.4	5.8	1.8	3000	29	98.0	0.05						98.0		200 ml of ML wasted for analyses
	23:0	7.4	5.7			28		0.08								
Jun-22	9:3	6.5	5.9	1.6	3000	29	98.0	0.36						97.7		pH probed cloged, pH ~ 6.5 for several hours
	22:0	7.4	5.8			28		0.18								
Jun-23	9:0	7.3	6.2	1.9	3000	29	130.0	0.05						98.3		
	17:0	7.4	5.9			29		0.08								
	22:0	7.3	5.8			30		0.06								
Jun-24	8	7.4	5.9	1.8	3000	30	130.0	0.07						130.0		200 ml of ML wasted for analyses
	17:0	7.3	5.9			30		0.28								
	22:0	7.4	5.8			29		0.36								

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (S.U.)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Jun-25	9:00	7.4	5.7	1.7	3000	29	130.0		0.18					129.9	0.02129	
	17:00	7.5	5.9			30			0.39							
	22:00	7.3	5.8			30			0.32							
Jun-26	9:00	7.4	6.1	1.8	3000	29	130.0		0.02				6100/8900	130.2	0.02134	Temp adjudted at 28 oC
	17:00	7.4	5.7			28			0.16				R = 0.685			250 ml of ML wasted for analyses
	22:00	7.4	5.9			27			0.12							
Jun-27	9:00	7.5	5.8	1.8	3000	28	130.0		0.05					130.0	0.02131	200 ml of ML wasted
	17:00	7.3	5.9			28			0.08							
	22:30	7.4	5.8			27			0.06							
Jun-28	10:00	7.4	5.7	1.6	3000	27	130.0		0.05					130.0	0.02203	Temp adjusted at 27 o C
	23:00	7.3	5.9			27			0.12							200 ml of ML wasted
Jun-29	8:00	7.4	5.8	1.6	3000	26	130.0		0.06					130.0	0.02203	
	22:30	7.3	6.1			27			0.04							
Jun-30	9:00	7.4	5.7	1.8	3000	26	130.0		0.05				5900/9100	130.0	0.02204	Temp adjusted at 26 oC
	17:00	7.4	5.9			27			0.09				R = 0.648			250 ml of ML wasted for analyses
	22:00	7.5	6.1			26			0.08							
Jul-01	8:00	7.3	6.2	1.9	3000	26	130.0		0.04					130.0	0.02204	200 ml of ML wasted
	22:00	7.4	6.1			26			0.06							
Jul-02	9:00	7.4	6.2	1.8	3000	26	130.0		0.04					130.0	0.02203	200 ml of ML wasted
	17:00	7.5	5.9			26			0.05							**Raw feed started**
	22:30	7.3	6.1			26			0.06							
Jul-03	9:00	7.4	6.2	1.9	3000	26	130.0		0.04					130.0		
	17:00	7.5	5.9			26			0.08							
	22:30	7.3	6.1			26			0.06							
Jul-04	8:00	7.4	6.2	2.6	3000	26	130.0		0.05					130.0		
	17:00	7.3	6.1			26			0.08							
	22:00	7.4	6.2			26			0.06							
Jul-05	9:00	7.4	5.9	2.2	3000	26	130.0		0.05					130.0	0.02453	Temp adjusted at 25 oC
	22:30	7.5	6.1			25			0.08							250 ml of ML wasted for analyses
Jul-06	8:00	7.3	5.9	2.1	3000	25	130.0		0.06					130.0	0.02453	
	22:00	7.4	6.1			26			0.05							
Jul-07	8:00	7.4	6.2	2.4	3000	25	130.0		0.12				5300/7500	129.9	0.02452	200 ml of ML wasted
	13:00	7.5	5.9			25			0.06				R = 0.706			New batch
	18:30	7.3	6.1			25			0.04							
	23:30	7.4	6.2			25			0.05							
Jul-08	9:00	7.3	5.9	1.9	3000	25	118.0		0.09					130.0	0.02453	200 ml of ML wasted
	13:00	7.4	6.1			25			0.17							
	23:30	7.4	6.2			25			0.12							200 ml of ML wasted
Jul-09	8:00	7.5	6.1	2.7	3000	25	118.0		0.05					118.0	0.02227	
	13:00	7.3	6.2			25			0.06							
	23:00	7.4	5.9			25			0.08							
Jul-10	8:00	7.4	6.1	2.5	3000	25	118.0		0.17					117.9		250 ml of ML wasted for analyses
	13:00	7.6	5.9			25			0.08							
	23:00	7.7	6.1			25			0.07							
Jul-11	9:00	7.5	6.2	2.2	3000	25	118.0		0.08					118.1		
	13:30	7.4	5.9			24			0.12							
	23:30	7.6	6.1			25			0.06							
Jul-12	9:00	7.5	6.2	2.4	3000	24	118.0		0.04					118.0	0.02409	Temp adjusted at 24oC
	23:00	7.4	6.1			24			0.05							250 ml of ML wasted for analyses
Jul-13	9:00	7.7	6.2	2.2	3000	25	118.0		0.06				4900/6600	118.0	0.02408	5 g PAC added
	23:00	7.3	5.9			24			0.04				R = 0.742			

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters						Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (St Un)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Jul-14	8:00	7.6	6.1	2.3	3000	24	118.0	0.05						118.0	0.02408	
	17:00	7.4	5.9			24		0.09								
	22:00	7.5	6.1			24		0.09								
Jul-15	9:00	9.6	5.9	1.9	3000	24	118.0	0.3						117.8	0.02403	pH probe mulfunction, soda ash overdose
	17:00	7.5	6.1			24		0.2								pH adjustment with H3PO4
	22:00	7.4	6.2			25		0.16								No change in feed
Jul-16	9:00	7.6	5.9	2.2	3000	25	118.0	0.16						118.1	0.02229	pH adjustment with H3PO4
	1:00	7.5	6.1			25		0.21								5 g PAC added, temp adjusted at 25 oC
	2:00	7.4	6.2			25		0.18								
Jul-17	9:00	7.7	6.1	2.1	3000	26	118.0	0.09					5300/7400	118.1	0.02228	15 g PAC added
	17:00	7.3	6.2			25		0.07					R= 0.716			temp adjusted at 26 oC
	22:00	7.6	5.9			25		0.12								
Jul-18	9:00	7.5	6.1	2.2	3000	26	118.0	0.09						118.0	0.02226	15 g PAC added
	17:00	7.4	5.9			26		0.08								
	22:00	7.6	6.1			25		0.07								
Jul-19	9:00	7.5	6.2	1.9	3000	26	118.0	0.09						118.0		1L ML exchanged with R # 1
	22:00	7.4	5.9			26		0.14								15 g PAC added
Jul-20	8:00	7.4	6.1	2.1	3000	26	118.0	0.02						118.1	0.01789	1L ML exchanged with R # 1
	22:00	7.3	5.9			26		0.09								10 g PAC added
Jul-21	9:00	7.6	6	2.1	3000	25	118.0	0.04					6600/8700	118.0	0.01788	1L ML exchanged with R # 1
	17:00	7.5	6.1			26		0.06					R = 0.758			
	22:00	7.4	6.2			26		0.08								
Jul-22	8:00	7.4	5.9	1.8	3000	26	164.0	0.04						118.0	0.01788	Aerators partly replaced
	17:00	7.4	6.4			26		0.05								Air flow adjusted
	22:00	7.3	6.6			26		0.06								
Jul-23	9:00	7.4	6.8	2.8	3000	26	164.0	0.05						164.0		air flow adjusted
	17:00	7.4	6.5			25		0.07								
	22:00	7.5	6.7			26		0.08								
Jul-24	9:00	7.3	6.8	3.1	3000	25	164.0	0.05						164.0	0.02247	Temp adjusted at 25 oC
	17:00	7.3	6.8			25		0.06								
	22:00	7.6	6.5			25		0.05								
Jul-25	9:00	7.5	7.6	3.8	3000	25	164.0	0.02					7300/9200	164.0	0.02247	Wasting 150 ml of ML
	17:00	7.4	6.8			25		0.08					R = 0.793			
	22:00	7.6	6.5			25		0.06								
Jul-26	9:00	7.3	6.7	2.8	3000	25	164.0	0.06						164.0	0.02246	Wasting 150 ml of ML
	22:00	7.6	6.8			24		0.03								
Jul-27	9:00	7.5	6.5	3.1	3000	24	164.0	0.05						164.0	0.02247	Wasting 150 ml of ML
	22:00	7.4	6.7			25		0.02								
Jul-28	8:00	7.3	6.8	2.9	3000	24	134.0	0.02						164.0		Wasting 150 ml of ML
	17:00	7.6	7.3			24		0.06								Temp adjusted at 24 oC
	22:00	7.5	6.5			24		0.04								
Jul-29	9:00	7.4	6.7	2.4	3000	24	134.0	0.03						134.0	0.02197	Wasting 200 ml of ML
	17:00	7.4	6.8			24		0.1								
	22:00	7.5	6.5			24		0.12								
Jul-30	9:00	7.3	6.7	2.6	3000	24	134.0	0.09					6100/7800	133.9	0.02196	Wasting 150 ml ML
	17:00	7.3	6.8			24		0.06					R = 0.782			
	22:00	7.6	6.5			23		0.08								
Jul-31	8:00	7.5	6.8	2.8	3000	23	134.0	0.05						134.0	0.02197	Wasting 150 ml ML
	17:00	7.5	6.5			23		0.04								
	22:00	7.6	6.7			23		0.09								
Aug-01	9:00	7.7	6.8	2.7	3000	23	134.0	0.1						134.0		Wasting 150 ml ML
	17:00	7.6	6.5			23		0.12								10 g PAC added
	22:00	7.5	6.7			23		0.08								Wasting 150 ml ML
Aug-02	9:00	7.5	6.8	2.9	3000	24	134.0	0.04						134.1		10 g PAC added
	22:00	7.6	6.5			23		0.06								Wasting 150 ml ML
Aug-03	9:00	7.7	6.7	3.1	3000	23	134.0	0.05						134.0	0.01970	Wasting 150 ml ML
	22:00	7.5	6.8			24		0.04								
Aug-04	9:00	7.3	6.5	2.8	3000	23	156.0	0.03					6800/8200	134.0	0.01971	Wasted 200 ml ML
	22:00	7.3	6.5			23		0.1					R = 0.82			5 g PAC added

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH (4 Un)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Aug-05	9:0	7.7	6.7	2.8	3000	23	156.0	0.06						156.0	0.02294	Wasting 150 ml ML
	17:0	7.6	6.8			23		0.08								Cooling coil installed
	22:0	7.5	6.5			23		0.04								5 g PAC added
Aug-06	8:3	7.2	6.7	3.1	3000	23	156.0	0.03						156.0		Wasted 100 ml ML
	17:0	7.6	6.7			23		0.06								Cooling adjustment
	23:0	7.7	6.8			22		0.08								5 g PAC added
Aug-07	9:0	7.6	6.9	4.2	3000	22	156.0	0.03						156.0	0.02167	Wasted 250 ml ML
	17:0	7.5	6.8			23		0.06								Cooling adjustment
	22:0	7.5	7.1			22		0.07								
Aug-08	9:0	7.6	7.2	4.6	3000	22	156.0	0.03					7200/9800	156.0	0.02167	Wasted 100 ml ML
	17:0	7.6	6.9			22		0.03					R = 0.735			
	22:0	7.7	6.8			22		0.06								
Aug-09	9:0	7.6	6.7	4.9	3000	23	156.0	0.04						156.0	0.02167	Cooling adjustment
	22:0	7.6	6.7			22		0.05								Wasted 150 ml ML
Aug-10	9:0	7.7	6.8	5.8	3000	22	144.0	0.02						156.0		Wasted 100 ml ML
	22:0	7.6	6.9			22		0.02								
Aug-11	8:3	7.5	7.2	5.1	3000	22	144.0	0.02						144.0	0.01756	Wasted 150 ml ML
	17:0	7.6	7.4			21		0.08								
	22:0	7.6	7.5			22		0.06								
Aug-12	9:0	7.7	7.6	5.4	3000	21	134.0	0.04					8200/10400	144.0	0.01756	Wasted 175 ml ML
	17:0	7.5	7.5			21		0.04					R = 0.788			Cooling adjustment
	22:0	7.3	7.6			22		0.06								
Aug-13	8:0	7.3	7.6	5.3	3000	21	134.0	0.04						134.0	0.01634	Wasted 150 ml ML
	17:0	7.6	7.9			21		0.02								
	22:0	7.7	8.1			21		0.02								
Aug-14	8:3	7.6	7.9	5.2	2000	21	89.3	0.02						134.0		No power since 4:20 pm
	16:0	7.8	4.2			23		0.08								No feed, no aeration
	22:0	7.6	0.5			24		0.04								Power restored at ~ 23:00
Aug-15	9:3	7.4	7.1	4.4	3000	23	142.0	0.03						89.3		Aerators partly replaced
	15:0	7.5	7.6			22		0.05								Cooling adjusted
	22:0	7.6	7.9			21		0.06								
Aug-16	9:3	7.6	8.1	5.2	3000	21	142.0	0.05						142.0		Cooling adjusted
	22:0	7.5	7.9			21		0.04								Wasted 175 ml ML
Aug-17	9:0	7.6	7.8	5.2	3000	22	142.0	0.06						142.0	0.01820	Aeration adjusted
	22:0	7.5	7.9			21		0.05								
Aug-18	8:3	7.6	8.1	5.3	3000	21	142.0	0.06					7800/9900	142.0	0.01821	Wasted 150 ml ML
	17:0	7.6	7.9			21		0.02					R= 0.787			
	22:0	7.5	8.1			21		0.07								
Aug-19	8:3	7.6	7.9	5.4	3000	21	142.0	0.04						142.0	0.01820	Cooling adjusted
	17:0	7.6	7.8			20		0.14								Wasted 175 ml ML
	22:0	7.7	7.9			21		0.22								
Aug-20	9:0	7.5	8.2	5.8	3000	20	142.0	0.06						142.1		Wasted 150 ml ML
	17:0	7.4	7.9			20.5		0.09								
	22:0	7.5	8.1			20.5		0.12								
Aug-21	8:0	7.6	7.9	5.3	3000	20	142.0	0.06						142.0	0.01973	Cooling adjusted
	17:0	7.5	8.1			20		0.09								Wasted 175 ml ML
	22:0	7.4	7.9			20		0.07								
Aug-22	8:0	7.4	7.8	5.2	3000	20	142.0	0.02					7200/9250	142.1	0.01973	Wasted 100 ml ML
	17:0	7.5	8.3			20		0.06					R = 0.778			
	22:0	7.4	7.9			20		0.08								
Aug-23	9:0	7.4	7.8	4.9	3000	20	142.0	0.02						142.0	0.01973	Wasted 100 ml ML
	22:0	7.5	7.9			20		0.05								
Aug-24	8:0	7.3	8.1	5.3	3000	19.5	200.0	0.03						142.0		Cooling adjusted
	22:0	7.3	7.9			20		0.04								
Aug-25	9:0	7.6	8.1	5.2	3000	19.5	200.0	0.05						200.0		Cooling adjusted
	17:0	7.5	7.9			19		0.06								Wasted 200 ml ML
	22:0	7.6	8.2			19		0.11								
Aug-26	8:0	7.7	7.9	4.9	3000	19	200.0	0.04						200.0		Wasted 100 ml ML
	17:00	7.6	8.1			19.5		0.12								

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters					TKN load (mg/L)	Effluent Analytical Data (mg/L)				MLVSS/MLTSS Ratio	NH3-N nitrif (mg/L)	NH3-nitri/VSS (mg/mg)	
		pH (Unit)	DO (mgO2/L)	DO (15 min)	Feed (ml)	Temp		COD	NH3-N	NO3-N	TSS	VSS			
	22:00	7.5	7.9			19		0.22							
Aug-27	9:00	7.6	7.9	4.8	3000	19	200.0	0.09					200.0	0.02816	700 ml ML taken for respirometry
	17:00	7.6	8.1			19.5		0.18							10 g PAC added
	22:00	7.5	7.9			19		0.22							
Aug-28	8:30	7.6	7.8	4.6	3000	19	200.0	0.9				7100/9300	199.2	0.02805	
	17:00	7.6	8.1			19		0.24				R = 0.763			
	22:00	7.5	8.1			19		0.26							
Aug-29	9:00	7.6	7.9	4.7	3000	19	144.0	0.12					200.8	0.02828	Cooling shut down
	17:00	7.7	7.8			22		0.06							
	22:00	7.6	8.1			23		0.08							
Aug-30	9:00	7.6	7.9	4.5	3000	28	144.0	0.04					144.1		Heating installed
	22:00	7.5	8.1			29		0.03							
Aug-31	9:00	7.6	7.9	4.8	3000	29	144.0	0.02					144.0	0.02150	
	21:00	7.7	7.8			28		0.04							
Sep-01	9:00	7.6	8.1	4.6	3000	29	144.0	0.03				6700/8300	144.0	0.02149	2.5 L ML replaced with water
	22:00	7.5	7.9			29		0.02				R = 0.81			
Sep-02	8:30	7.6	7.8	4.5	3000	30	144.0	0.03					144.0	0.02149	1.0 L ML replaced with water
	17:00	7.2	7.2			30		0.08							
	22:00	7.6	6.9			29		0.06							
Sep-03	8:30	7.6	6.8	3.8	3000	30	160.0	0.03					144.0		1.0 L ML replaced with water
	17:00	7.5	6.7			29		0.07							
	22:00	7.6	6.9			30		0.04							
Sep-04	9:00	7.7	6.6	3.2	3000	30	160.0	0.03					160.0	0.03333	1.0 L ML replaced with water
	16:00	7.6	6.8			29		0.04							
	22:00	7.6	6.7			30		0.03							
Sep-05	8:30	7.5	6.8	3.1	3000	30	160.0	0.04				4800/6200	160.0	0.03333	Wasted 175 ml ML
	17:00	7.6	6.7			29		0.03				R = 0.77			
	22:00	7.6	6.9			30		0.02							
Sep-06	9:00	7.6	6.8	3.3	3000	31	160.0	0.04					160.0	0.03333	450 mg FeCl3 added
	22:00	7.5	6.8			30		0.04							
Sep-07	9:00	7.6	6.7	3.2	3000	30	160.0	0.03					160.0		450 mg FeCl3 added
	22:00	7.7	6.9			29		0.02							
Sep-08	8:30	7.6	6.6	3.2	3000	30	160.0	0.04					160.0	0.03265	600 mg FeCl3 added
	17:00	7.5	6.6			29		0.04							
	22:00	7.4	6.8			29		0.03							
Sep-09	8:30	7.4	6.7	3.3	3000	30	160.0	0.02				4900/6600	160.0	0.03266	600 mg FeCl3 added
	17:00	7.5	6.8			30		0.04				R = 0.742			Wasted 175 ml ML
	22:00	7.3	6.6			29		0.04							
Sep-10	9:00	7.3	6.8	3.4	3000	29	160.0	0.03					160.0	0.03265	600 mg FeCl3 added
	16:00	7.6	6.7			29		0.02							Wasted 150 ml ML
	22:00	7.5	6.8			30		0.04							
Sep-11	9:00	7.3	6.6	3.2	3000	30	160.0	0.03					160.0	0.03137	900 mg FeCl3 added
	16:00	7.4	6.6			29		0.04							Wasted 150 ml ML
	22:00	7.4	6.8			29		0.03							
Sep-12	9:00	7.4	6.7	3.3	3000	30	160.0	0.04				5100/7000	160.0	0.03137	900 mg FeCl3 added
	17:00	7.4	6.8			30		0.03				R = 0.728			Wasted 150 ml ML
	22:00	7.4	6.6			29		0.04							
Sep-13	9:00	7.5	6.8	3.2	3000	30	160.0	0.03					160.0	0.03137	Temp adjusted at 27 oC
	22:00	7.3	6.7			28		0.02							900 mg FeCl3 added
Sep-14	8:30	7.3	6.8	3.2	3000	27	160.0	0.04					160.0		
	22:00	7.4	6.7			28		0.04							
Sep-15	8:30	7.3	6.6	3.1	3000	27	160.0	0.03					160.0		900 mg FeCl3 added
	17:00	7.3	6.6			27		0.03							Wasted 100 ml ML
	22:00	7.4	6.6			27		0.02							
Sep-16	9:00	7.4	6.8	3.3	3000	26	160.0	0.04					160.0		Temp. adjusted at 25 oC
	17:00	7.4	6.7			25		0.04							900 mg FeCl3 added
	22:00	7.4	6.8			25		0.03							
Sep-17	9:00	7.4	6.6	3.1	3000	25	160.0	0.02					160.0		500 ml ML replaced with water
	16:00	7.5	6.8			24		0.04							900 mg FeCl3 added

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	Time	Operational Parameters					Effluent Analytical Data (mg/L)					MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH - SU (In)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3-N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
	2[illegible]0	7.3	6.7			25		0.04								
Sep-18	9[illegible]	7.3	6.8	3.1	3000	24	178.0	0.03						160.0	0.03019	Temp. adjusted at 23 oC
	1[illegible]0	7.4	6.9			23		0.04								Wasted 100 ml ML
	2[illegible]0	7.4	6.6			24		0.03								
Sep-19	9[illegible]	7.5	6.6	2.9	3000	23	178.0	0.04					5300/7600	178.0	0.03358	600 mg FeCl3 added
	1[illegible]0	7.3	6.8			23		0.03					R = 0. 697			Wasted 100 ml ML
	2[illegible]0	7.4	6.7			23		0.02								
Sep-20	8[illegible]	7.4	6.8	3.2	3000	22	178.0	0.04						178.0	0.03358	600 mg FeCl3 added
	2[illegible]0	7.5	6.6			23		0.04								Wasted 150 ml ML
Sep-21	8[illegible]	7.3	6.8	3.1	3000	23	178.0	0.03						178.0		600 mg FeCl3 added
	2[illegible]0	7.3	6.7			22		0.03								
Sep-22	9[illegible]	7.4	6.8	3.2	3000	22	178.0	0.02						178.0	0.03123	600 mg FeCl3 added
	1[illegible]0	7.5	6.6			23		0.04								Wasted 150 ml ML
	2[illegible]0	7.4	6.6			23		0.04								
Sep-23	8[illegible]	7.5	6.8	3.3	3000	23	178.0	0.03					5700/7500	178.0	0.03123	600 mg FeCl3 added
	1[illegible]0	7.3	6.7			22		0.02					R = 0.76			**3000 ml ML exchanged with R1**
	2[illegible]0	7.3	6.8			22		0.04								Wasted 100 ml ML
Sep-24	9[illegible]	7.4	6.9	3.2	3000	23	178.0	0.04						178.0	0.03123	600 mg FeCl3 added
	1[illegible]0	7.4	6.8			23		0.05								**2000 ml ML exchanged with R1**
	2[illegible]0	7.5	6.7			22		0.03								
Sep-25	8[illegible]	7.3	6.7	3.1	3000	22	178.0	0.04						178.0		600 mg FeCl3 added
	1[illegible]0	7.4	6.6			23		0.03								Wasted 100 ml ML
	2[illegible]0	7.4	6.6			23		0.04								
Sep-26	9[illegible]	7.5	6.6	3.2	3000	23	178.0	0.03						178.0		600 mg FeCl3 added
	2[illegible]0	7.3	6.8			22		0.04								Wasted 100 ml ML
Sep-27	9[illegible]	7.4	6.7	3.1	3000	22	178.0	0.03						178.0		600 mg FeCl3 added
	2[illegible]0	7.3	6.8			23		0.04								
Sep-28	9[illegible]	7.4	6.7	3.1	3000	23	178.0	0.03						178.0	0.03633	600 mg FeCl3 added
	2[illegible]0	7.5	6.6			22		0.02								Wasted 150 ml ML
Sep-29	9[illegible]	7.4	6.6	2.9	3000	23	178.0	0.04					4900/6600	178.0	0.03632	600 mg FeCl3 added
	1[illegible]0	7.3	6.6			23		0.04					R = 0.742			Wasted 150 ml ML
	2[illegible]0	7.4	6.7			23		0.03								
Sep-30	8[illegible]	7.5	6.6	3.1	3000	22	178.0	0.03						178.0	0.03633	600 mg FeCl3 added
	1[illegible]0	7.4	6.7			22		0.02								Wasted 150 ml ML
	2[illegible]0	7.5	6.6			23		0.05								**3000 ml ML exchanged with R1**
Oct-01	9[illegible]	7.3	6.8	3.3	3000	23	178.0	0.06						178.0		600 mg FeCl3 added
	1[illegible]0	7.6	6.8			23		0.04								**3000 ml ML exchanged with R1**
	2[illegible]0	7.8	6.9			23		0.03								
Oct-02	9[illegible]	7.7	6.8	3.2	3000	22	178.0	0.02						178.0		**3000 ml ML exchanged with R1**
	1[illegible]0	7.6	6.7			22		0.04								Wasted 150 ml ML
	2[illegible]0	7.8	6.7			23		0.04								600 mg FeCl3 added
Oct-03	9[illegible]	7.5	6.8	3.1	3000	23	178.0	0.03						178.0		**1000 ml ML exchanged with R1**
	1[illegible]0	7.6	6.9			22		0.03								Wasted 150 ml ML
	2[illegible]0	7.8	6.8			22		0.02								600 mg FeCl3 added
Oct-04	8	7.7	6.7	2.9	3000	23	178.0	0.04						178.0	0.03369	Wasted 150 ml ML
	2[illegible]0	7.6	6.7			23		0.04								600 mg FeCl3 added
Oct-05	9[illegible]	7.8	6.6	2.8	3000	23	178.0	0.03					4600/6500	178.0	0.03370	Wasted 150 ml ML
	2[illegible]0	7.6	6.6			22		0.02					R = 0.707			600 mg FeCl3 added
Oct-06	8[illegible]	7.8	6.6	2.9	3000	22	178.0	0.04						178.0	0.03369	Wasted 150 ml ML
	1[illegible]0	7.6	6.8			23		0.04								600 mg FeCl3 added
	2[illegible]0	7.8	6.7			23		0.03								
Oct-07	8[illegible]	7.7	6.8	3.1	3000	22	178.0	0.04						178.0		Wasted 200 ml ML
	1[illegible]0	7.6	6.7			23		0.03								600 mg FeCl3 added
																Feed changed 1 hr with mixing only
	2[illegible]0	7.8	6.6			23		0.04								
Oct-08	9[illegible]	7.7	6.8	2.9	3000	23	178.0	0.07						178.0		Wasted 100 ml ML
	1[illegible]0	7.6	6.6			22		0.03								600 mg FeCl3 added
	2[illegible]0	7.7	6.8			22		0.02								

TABLE E2C

SUMMARY OF ANALYTICAL DATA AND OPERATIONAL PARAMETERS FOR SBR2

Date	time	Operational Parameters						Effluent Analytical Data (mg/L)					MLVSS/MLTSS	NH3-N nitrif	NH3-nitr/VSS	
		pH - SU (In)	DO (mg/L)	DO (15 min)	Feed (ml)	Temp	TKN load (mg/L)	COD	NH3-N	NO3 N	TSS	VSS	Ratio	(mg/L)	(mg/mg)	
Oct-09	8:[illegible]	7.6	6.9	2.8	3000	22	178.0	0.04						178	0.03956	600 mg FeCl3 added
	17:00	7.8	6.8			23		0.04								Wasted 150 ml ML
	22:00	7.6	6.7			23		0.03								
Oct-10	8:[illegible]	7.8	6.7	2.6	3000	23	178.0	0.02					4500/6600	178	0.03956	600 mg FeCl3 added
	17:00	7.6	6.8			22		0.04					R = 0.681			Wasted 150 ml ML
	22:00	7.8	6.8			22		0.03								**Heater removed**
Oct-11	9:[illegible]	7.7	6.9	2.5	3000	21	178.0	0.02						178	0.03956	600 mg FeCl3 added
	22:00	7.7	6.8			20		0.04								Wasted 150 ml ML
Oct-12	9:[illegible]	7.6	6.7	2.8	3000	20	178.0	0.04						178		600 mg FeCl3 added
	22:00	7.8	6.7			20		0.03								
Oct-13	9	7.6	6.8	2.6	3000	20	178.0	0.02						178	0.04564	Wasted 200 ml ML
	22:00	7.8	6.9			20		0.04								600 mg FeCl3 added
Oct-14	8:[illegible]	7.6	6.8	2.6	4000	19	237.3	0.04					3900/6100	237	0.06077	**4 days HRT with 75 min feed without air**
	17:00	7.8	6.7			19		0.05					R = 0.64			Wasted 200 ml ML
	22:00	7.7	6.9			19		0.11								600 mg FeCl3 added
Oct-15	8:[illegible]	7.9	6.9	2.8	4000	20	237.3	0.03						237	0.07645	Wasted 250 ml ML
	17:00	7.8	6.8			19		0.09								600 mg FeCl3 added
	22:00	7.8	7.1			19		0.12								
Oct-16	9	7.9	7.2	3.1	4000	19	237.3	0.04					3100/5200	237	0.07645	Wasted 250 ml ML
	17:00	7.8	7.4			19		0.03					R = 0.6			600 mg FeCl3 added
	22:00	8.1	7.6			19		0.06								
Oct-17	8:[illegible]	8.1	7.5	3.4	1400	19	83.1	0.02								**Last feed to the system**
	17:00	7.8	7.8			19		0.04								200 mg FeCl3 added

TAB E3

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION CLAIRTON SLUDGE
SUMMARY OF DATA FOR REACTOR #3 (BACK UP)

Date	Time	Operational Parameter						Analyses	Comments
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Fe (ml) Water	Groundwater	Temperature (oC)	NH3-N	
Feb-09	9:30	7.3	5.6	2.3	0	0	18	0.3	
	16:30	7.6	5.4	2.4	0	0	19	0.15	2.0 ml buffer
Feb-10	9:30	7.6	5.6	2.3	300	0	18	0.16	
	17:00	7.4	5.3	2.4	100	0	18	0.08	foaming
Feb-11	9:30	7.5	5.2	2.7	300	100	17	0.2	
	17:00	6.9	5.8	2.6	150	0	18	0.18	3.0 g Na2CO3
Feb-12	9:30	7.6	5.3	2.3	500	100	19	0.3	
	17:00	7.3	6.2	3.4	100	0	19	0.12	1.0 ml buffer
Feb-13	9:30	7.4	5.2	2.1	200	100	19	0.1	some foaming
	16:30	6.9	5.8	2.6	300	0	18	0.1	
Feb-14	9:30	7.8	5.6	2.2	300	100	18	0.1	2.0 g Na2CO3
	16:30	8	5.8	2.4	200	0	17	0.15	
Feb-15	9:00	7.6	5.4	2.3	300	200	18	0.1	
	17:00	7.5	5.5	2.2	300	0	18	0.25	
Feb-16	9:00	7.6	5.6	2.1	200	200	18	0.2	
	16:30	7.2	5.9	2.5	350	0	18	0.3	1.0 ml buffer
Feb-17	9:00	7.3	6.2	2.1	400	200	18	0.4	
	17:00	7.2	5.8	2.3	350	0	18	0.2	some foaming
Feb-18	9:30	7.6	5.6	2.2	300	200	19	0.3	
	16:30	7.1	5.5	2.4	400	0	18	0.35	
Feb-19	9:00	6.9	5.4	2.1	300	200	18	0.2	2.5 g Na2CO3
	16:30	7.6	5.8	2.3	300	0	18	0.25	
Feb-20	9:00	7.8	5.6	1.9	350	250	19	0.25	1.0 ml buffer
	17:00	7.6	5.6	2.2	400	0	19	0.45	
Feb-21	9:30	7.4	6.2	2.2	350	250	19	0.35	solids recycled R # 1 & 2
	16:30	8.2	5.5	2.4	200	0	19	0.75	
Feb-22	9:00	7.6	5.8	2.3	400	250	18	0.6	solids recycled R # 1 & 2
	17:00	7.5	5.6	2.2	300	0	18	0.3	
Feb-23	9:30	7.8	5.4	1.9	750	250	18	0.2	solids recycled R # 1 & 2
	16:30	6.9	5.6	2.2	0	0	18	0.35	
Feb-24	9:30	7.2	5.6	2.2	350	300	18	0.25	1.5 g Na2CO3
	16:30	7.8	6.2	2.7	400	0	18	0.55	
Feb-25	9:30	7.6	5.4	2.2	400	300	18	0.3	solids recycled R # 1 & 2
	17:00	7.4	5.8	2.3	400	0	18	0.6	
Feb-26	9:00	7.6	5.2	1.9	350	300	18	0.35	solids recycled R # 1 & 2
	17:00	7.3	5.5	2.4	450	0	18	0.65	
Feb-27	9:30	7.2	5.6	2.1	400	300	18	0.3	1.5 g Na2CO3, 1 ml buffer
	17:00	7.1	6.2	2.6	400	0	18	0.5	

TABLE E3

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION CLAIRTON SLUDGE
SUMMARY OF DATA FOR REACTOR #3 (BACK UP)

Date	Time	Operational Parameters						Analyses	Comments
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml)		Temperature (oC)	NH3-N	
					Water	Groundwater			
Feb-28	9:30	7.9	5.4	2.2	500	300	18	0.2	solids recycled R # 1 & 2
	17:00	7.3	5.5	2.4	300	0	19	0.6	
Mar-01	9:00	7.8	5.2	2.2	350	300	18	0.15	solids recycled R # 1 & 2
	17:00	7.5	5.7	2.6	400	0	18	0.45	
Mar-02	9:30	7.6	5.4	1.8	500	300	18	0.35	solids recycled R # 1 & 2
	17:00	7.4	5.9	2.5	300	0	18	0.65	
Mar-03	9:30	7.7	5.4	2.2	400	300	18	0.15	solids recycled R # 1 & 2
	16:30	7.3	6.3	1.4	400	0	18	0.25	
Mar-04	9:30	7.4	6.1	2.7	500	300	18	0.1	solids recycled R # 1 & 2
	17:30	7.8	5.8	2.3	600	0	19	1.3	
Mar-05	8:30	7.6	5.6	2.2	650	250	19	2.2	
	17:00	7.4	5.4	1.8	500	0	18	0.7	2.0 ml buffer
Mar-06	9:00	7.6	5.6	2.2	300	250	18	0.2	
	17:00	7.3	5.6	2.2	600	0	18	0.5	1.0 g soda ash
Mar-07	9:30	7.2	6.2	2.7	700	250	18	0.35	
	17:00	7.8	5.4	2.2	450	0	18	0.5	
Mar-08	9:30	7.6	5.8	2.3	500	250	18	0.22	
	17:30	7.4	5.2	1.9	350	0	18	0.15	
Mar-09	8:30	7.6	5.5	2.4	600	250	18	0.18	
	17:30	7.3	5.6	2.1	800	0	18	0.34	
Mar-10	9:00	7.2	5.4	2.2	500	250	18	0.22	
	18:00	7.1	6.3	1.4	600	0	19	0.18	
Mar-11	9:00	7.7	6.1	2.7	600	0	19	0.3	
	17:30	7.5	5.8	2.3	500	250	19	0.2	
Mar-12	9:00	7.4	5.6	2.2	450	0	19	0.15	
	17:00	7.8	5.6	2.2	500	300	19	0.2	2.0 g soda ash
Mar-13	9:00	7.6	5.4	2.6	600	0	18	1.1	
	16:30	7.4	5.6	2.7	500	0	18	0.8	
Mar-14	8:30	7.6	5.6	2.2	500	0	18	0.2	
	17:00	7.3	5.6	2.3	400	300	19	0.2	
Mar-15	9:00	7.2	5.4	2.8	600	0	18	2.2	1ml buffer
	17:00	7.8	5.6	2.2	600	0	18	0.6	
Mar-16	9:00	7.3	5.6	2.7	500	0	18	0.2	
	16:30	7.2	6.2	2.2	500	300	18	0.15	2.0 g soda ash
Mar-17	9:00	7.8	5.4	2.3	400	0	18	0.8	
	17:30	7.2	6.7	3.6	400	300	19	0.2	3.0 g soda ash

TABLE E3

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION CLAIRTON SLUDGE
SUMMARY OF DATA FOR REACTOR #3 (BACK UP)

Date	Time	Operational Parameters						Analyses	Comments
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml)		Temperature	NH3-N	
					Water	Groundwater	(oC)		
Mar-18	8:30	7.8	7.2	2.9	500	0	19	1.5	
	18:00	7.7	7	_	200	0	19	0.54	
	23:00	7.6	6.8	_	0	0	18	0.85	
Mar-19	8:30	8.2	7.5	3.2	300	300	19	0.18	3.0 g soda ash
	17:00	7.7	8.2	_	300	0	19	0.21	
	23:00	7.8	7.4	_	0	0	19	0.16	
Mar-20	9:00	7.5	7.6	3.4	400	300	19	0.25	2.0 g soda ash
	17:00	7.8	7.3	_	200	0	19	0.35	
	23:00	7.7	7.4	_	0	0	18	0.3	
Mar-21	9:00	7.5	7.8	3.6	500	0	18	0.2	
	17:00	7.6	7.4	_	100	300	19	0.33	1.0 g soda ash
	23:00	7.8	7.3	_	0	0	19	0.55	
Mar-22	9:30	7.7	7.3	3.2	300	0	19	0.24	
	16:30	7.6	7.2	_	500	300	19	0.21	
	23:00	7.5	7.5	_	0	0	19	0.25	
Mar-23	9:30	7.3	6.9	3.1	400	0	19	0.22	1.0 g soda ash
	16:00	7.7	7.2	_	100	300	19	0.2	
	23:00	7.5	6.8	_	0	0	19	0.58	
Mar-24	9:00	7.7	7	3.1	500	300	19	0.32	1.0 ml buffer
	17:00	7.5	7.8		200	0	20	0.26	2.0 g soda ash
	23:00	7.8	6.7		0	0	19	0.12	
Mar-25	9:00	7.9	7.6	3.7	400	300	19	0.22	
	16:30	8.2	7.8		300	0	20	0.36	
	23:00	7.7	7.5		0	0	20	0.2	
Mar-26	9:00	8	7.4	3.9	400	300	19	0.18	1.0 ml buffer
	17:00	7.6	7.3		200	0	19	0.28	2.0 g soda ash
	23:00	7.7	7.2		0	0	19	0.22	
Mar-27	9:00	7.5	6.8	3.3	500	300	20	0.18	2.0 g soda ash
	16:30	7.8	6.6		200	0	19	0.32	2.0 ml buffer
	23:00	7.7	7.5		0	0	20	0.2	
Mar-28	9:00	7.8	7.5	3.4	200	350	20	0.25	
	16:30	7.6	7.8		300	0	20	0.2	2.0 g soda ash
	23:00	7.4	7.3		0	0	20	0.22	2.0 ml buffer
Mar-29	9:00	7.8	7.5	3.6	250	350	19	0.16	
	16:30	7.5	7.4		200	0	19	0.18	
	23:00	7.7	7.2		0	0	20	0.23	

TABLE E3

WAUKEGAN NITRIFICATION STUDY - ACCLIMATIZATION CLAIRTON SLUDGE
SUMMARY OF DATA FOR REACTOR #3 (BACK UP)

Date	Time	Operational Parameters						Analyses	Comments
		pH (St Un)	DO (mgO2/L)	DO(15 min)	Feed (ml) Water	Feed (ml) Groundwater	Temperature (oC)	NH3-N	
Mar-30	9:00	8.1	6.8	3.5	250	350	20	0.2	2.0 ml buffer
	16:30	7.6	6.9		0	0	20	0.28	2.0 g soda ash
	23:00	7.5	7.2		0	0	20	0.26	
Mar-31	9:30	7.8	7.2	3.4	450	350	20	0.15	2.0 ml buffer
	17:00	7.8	7.8		0	0	19	0.22	2.0 g soda ash
	23:00	7.5	7.4		0	0	18	0.2	
Apr-01	9:30	8.2	7.5	3.3	500	350	19	0.17	
	16:00	7.8	8.1		0	0	18	0.19	
	23:00	7.6	7.6		0	0	18	0.15	
Apr-02	9:00	7.4	7.4	3.2	0	200	18	0.18	2.0 g soda ash
	17:00	7.8	7.2		400	200	20	0.22	2.0 ml buffer
	23:00	7.6	6..9		0	0	19	0.32	
Apr-03	9:00	7.4	7.5	3.3	300	200	18	0.18	2.0 g soda ash
	17:00	7.9	7.4		0	200	19	0.24	2.0 ml buffer
	23:00	7.7	6.9		0	0	18	0.22	
Apr-04	9:00	7.5	7.6	3.5	200	200	19	0.18	
	17:00	7.6	7.2		400	200	18	0.21	
	23:00	7.5	7.8		0	0	18	0.26	
Apr-05	9:00	7.8	7.4		300	200	20	0.22	2.0 g soda ash
	17:00	7.8	7.5		0	200	19	0.18	2.0 ml buffer
	23:00	7.6	7.2		0	0	18	0.17	
Apr-06	9:00	7.5	7.8	3.8	400	200	19	0.23	
	17:00	7.8	7.4		0	200	18	0.16	
	23:00	7.8	7.5		0	0	19	0.18	
Apr-07	9:00	7.8	7.4	3.9	200	200	19	0.17	2.0 g soda ash
	16:30	7.6	7.5		0	200	18	0.18	
	23:00	7.5	7.2		0	0	19	0.16	
Apr-08	8:30	7.8	7.8	3.5	400	200	18	0.14	2.0 ml buffer
	17:00	7.6	7.4		0	0	19	0.24	
	23:00	7.5	6.9		0	0	19	0.22	
Apr-09	9:30	7.8	7.6	3.6	0	200	18	0.13	2.0 g soda ash
	17:00	7.8	7.2		0	0	19	0.22	2.0 ml buffer
	23:00	7.6	7.8		0	0	18	0.18	
Apr-10	9:00	7.5	7.4	3.3	0	200	19	0.24	

APPENDIX F

BIOKINETICS MEASUREMENTS

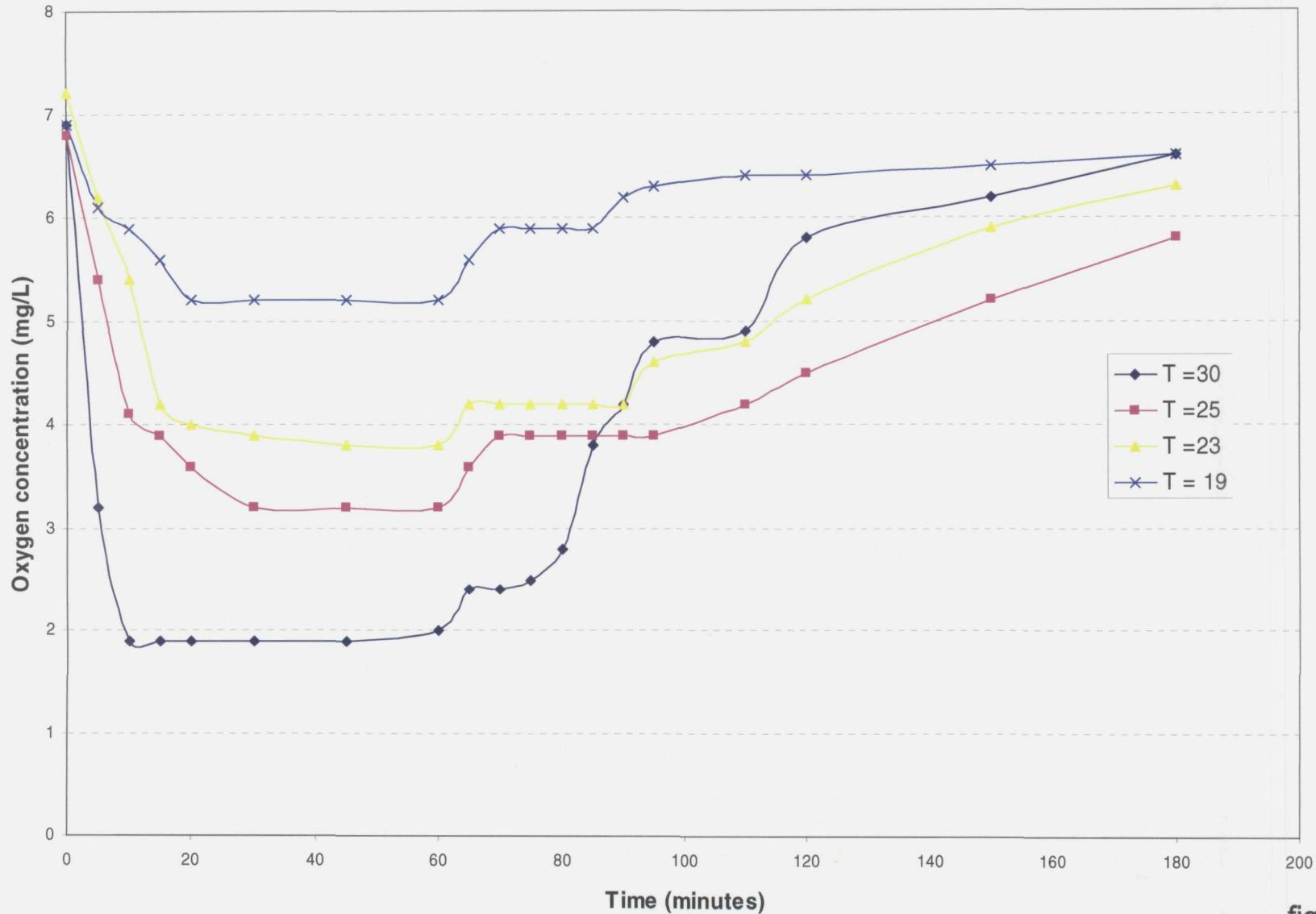


figure F.1

DISSOLVED OXYGEN CONCENTRATION IN SBR2
DURING AND AFTER FEED CYCLE AT DIFFERENT TEMPERATURES AT 5 DAYS HRT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

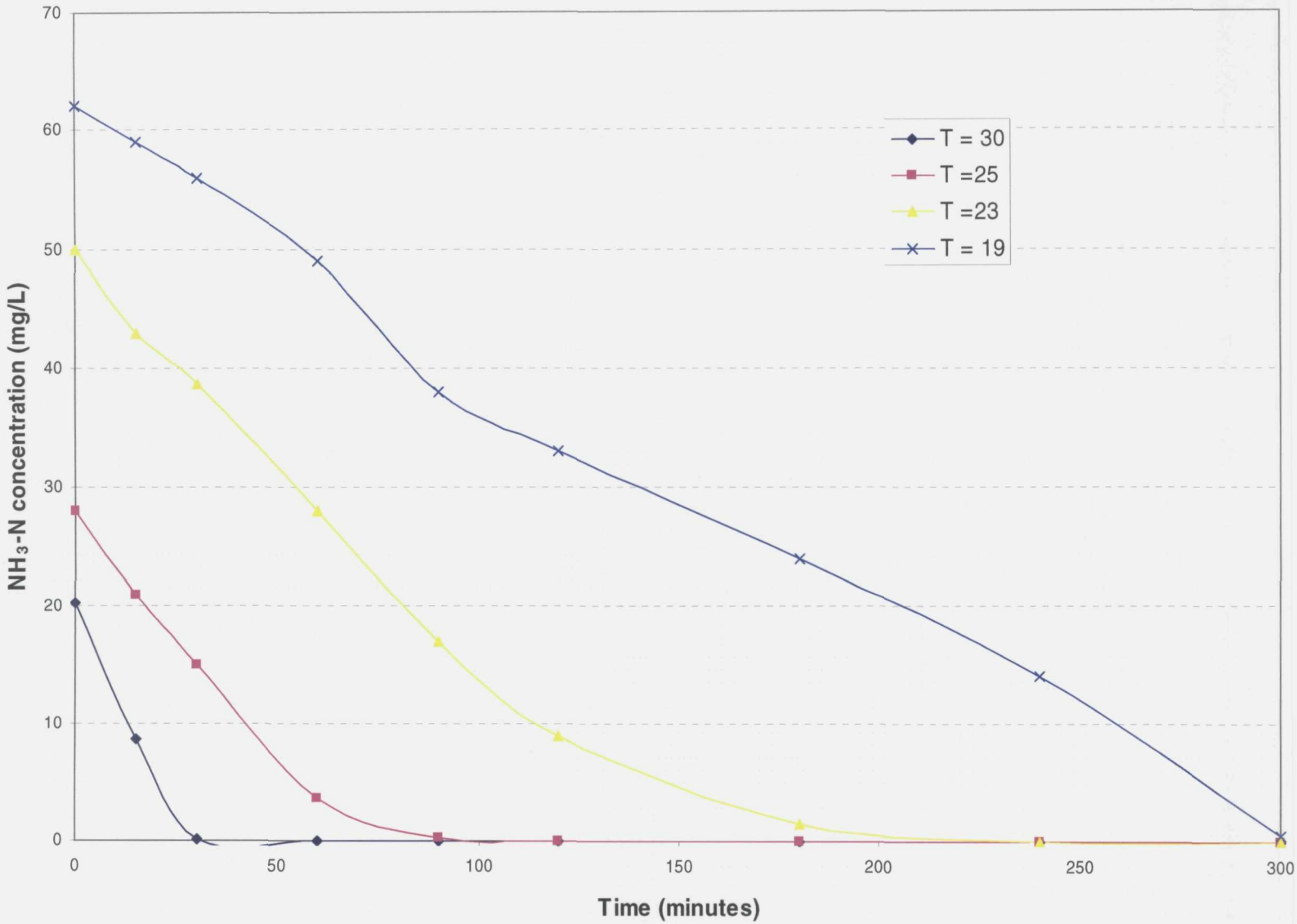


figure F.2

AMMONIA CONCENTRATION IN SBR2
DURING AND AFTER FEED CYCLE AT DIFFERENT TEMPERATURES AT 5 DAYS HRT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

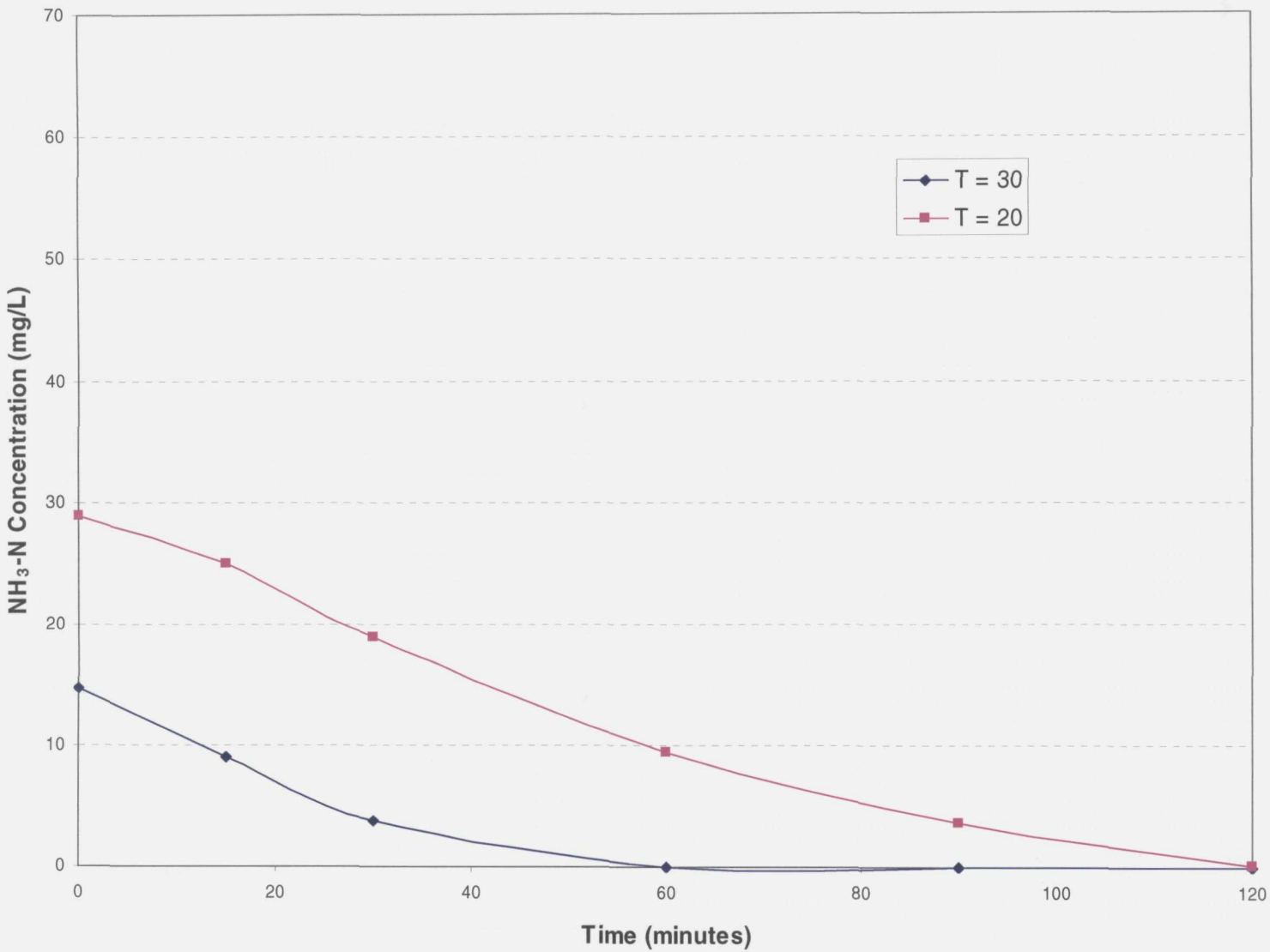


figure F.3

AMMONIA CONCENTRATION IN SBR2
DURING AND AFTER FEED CYCLE AT DIFFERENT TEMPERATURES AT 3 DAYS HRT
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

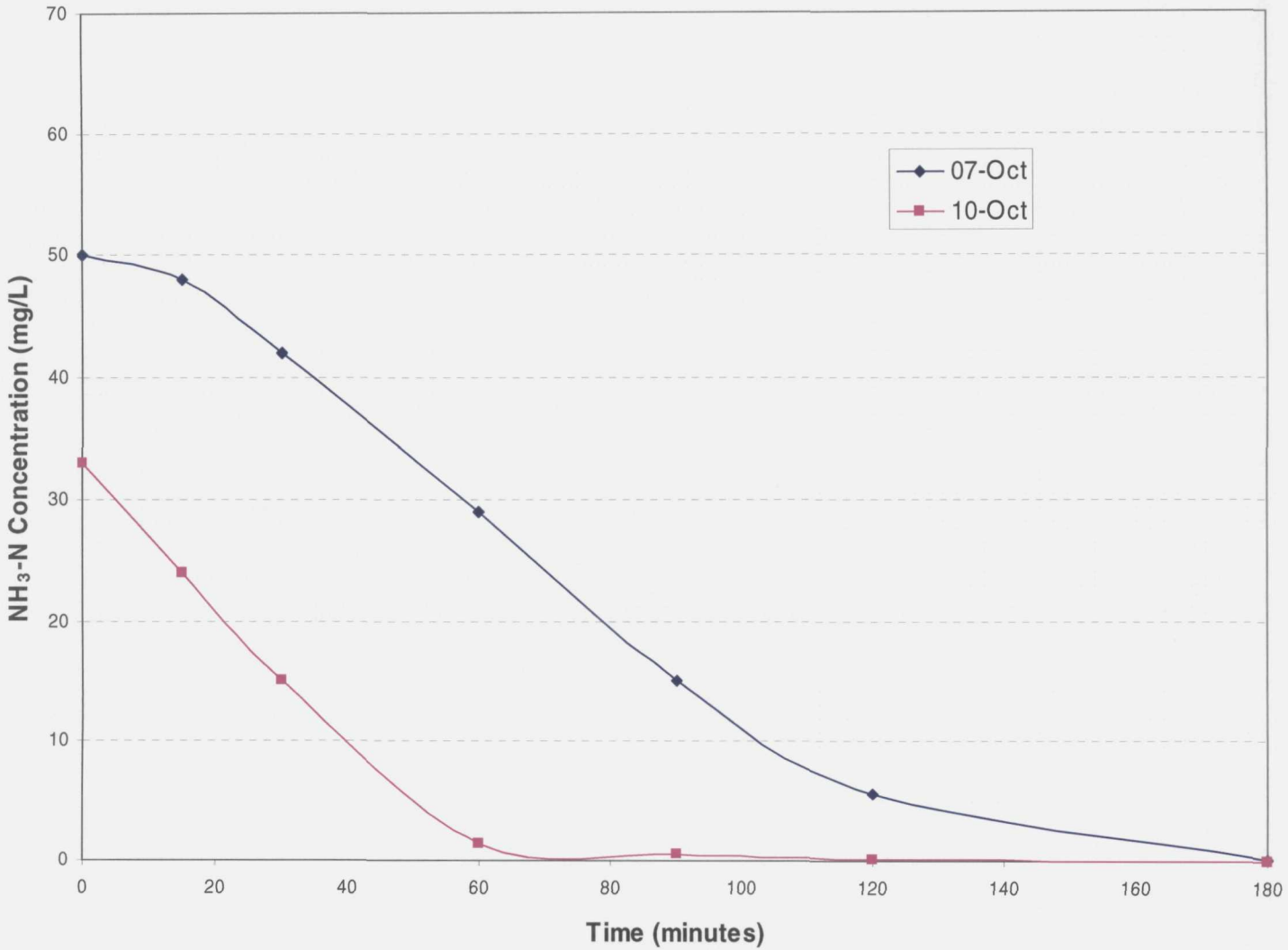


figure F.4

BIOKINETICS OF NH3-N IN REACTOR SBR2
OPERATED AT 4 DAYS HRT 22°C WITH FEED CYCLE WITHOUT AERATION
WAUKEGAN MANUFACTURED GAS AND COKE PLANT SITE
Waukegan, Illinois

TABLE F.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	Measurement time	Reactor # 1		Rate (C0 -Ct)/t [mg NH3-N/min]	Reactor # 2		Rate (C0 -Ct)/t [mg NH3-N/min]
		DO (mgO2/L)	NH3-N (mg/L)		DO (mgO2/L)	NH3-N (mg/L)	
Jun-03	Before feed	6.42	0.06		6.2	0.08	
	30 min feed	3.9	6.5		3.45	7.2	
	60 min feed	2.23	32		3.15	38	
	After feed						
	30 min	4.36	18	1.46	4.56	22	0.53
	60 min	5.48	1.12	1.51	5.66	2.6	0.59
Jun-06	Before feed	5.9	0.07		6.12	0.12	
	30 min feed	3.5	6.8		3.35	8.6	
	60 min feed	2.1	29		2.98	31	
	After feed						
	30 min	4.93	3.5	1.85	4.88	8.3	0.75
	60 min	5.6	0.38	1.47	6.02	0.65	0.51
Jun-13	Before feed	5.9	0.06		6.2	0.08	
	30 min feed	3.55	6.5		3.48	8.1	
	60 min feed	2.3	28		2.88	32	
	After feed						
	30 min	4.3	2.8	0.84	5.6	10.6	0.71
	60 min	5.9	0.22	0.46	6.2	0.38	0.53
Jun-17	Before feed	5.9	0.08		6.2	0.06	
	15 min feed	2.58	3.9		3.4	4.2	
	30 min feed	2.96	9.2		3.2	10.3	
	60 min feed	1.98	27		2.96	25	
	After feed						
	15 min	2.58	19.3		3.08	10.5	
	30 min	2.98	8.2	0.63	4.05	5.5	0.65
	60 min	4.9	0.08	0.45	5.6	0.14	0.41
Jun-20	Before feed	6.18	0.05		6.15	0.04	
	15 min feed	1.89	3.5		2.6	3.2	
	30 min feed	2.1	6.6		2.9	5.8	
	45 min feed	2.2	10.2		3.4	8.5	
	60 min feed	2.25	14		3.6	10.5	
	After feed						
	15 min	2.6	3.5		2.5	2.8	
	30 min	4.8	0.98	0.13	4.3	0.26	0.34
	60 min	5.4	0.06	0.23	5.8	0.07	0.174
Jun-21	Before feed	5.9	0.04		6.2	0.06	
	After feed	1.9	10.5		2.6	8.5	
	15 min	2.3	3.05		4.27	1.8	
	30 min	4.7	0.2		5.4	0.14	
	60 min	5.6	0.05		5.9	0.07	

TABLE I 1

SUMMARY OF BIOKINETI S MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	I ate (C(-Ct)/t [mg N] 3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Jun-24	Before feed	5.95	0.06	T = 30o '	6.05	0.05	T = 30oC
	15 min feed	1.7	5.1		1.95	4.3	
	30 min feed	1.85	8.2		2.2	5.1	
	45 min feed	2.3	9		2.2	5.6	
	60 min feed	2.5	9.1		2.4	7.8	
	After feed						
	5 min	3.15			2.9		
	10 min	3.6			3.8		
	15 min	4.8	0.16	1.6	5.1	0.12	0.51
	20 min	5.45			5.3		
	25 min	5.5			5.6		
	30 min	5.6	0.05	1.3	5.8	0.07	0.25
Jun-26	Before feed	6.05	0.04	T = 30o	5.9	0.05	T = 28oC
	5 min feed	3.7			3.5		
	10 min feed	2.5	1.3		2.3	2.6	
	15 min feed	2.35			2.2		
	20 min feed	2.4	1.5		2.01	2.8	
	30 min feed	2.5	1.4		1.8	3.1	
	40 min feed	2.65	1.1		1.9	4.2	
	60 min feed	2.65	1.2		1.9	4.8	
	After feed						
	5 min	5.05			3.7		
	10 min	5.4	0.12		3.8	0.18	
	15 min	5.5			5.1		
	20 min	5.55	0.06		5.2	0.08	
	25 min	5.65			5.35		
	30 min	5.9	0.04		5.5	0.05	
Jun-28	Before feed	6.2	0.04	T = 30o(	6.1	0.05	T = 27oC
	5 min feed	3.5			4.8		
	10 min feed	2.4	1.8		4.5		
	15 min feed	1.8			4.25		
	20 min feed	1.7	2.2		4.16	20.5	
	30 min feed	1.6	2.6		3.06	21.5	
	40 min feed	1.5			3.05	23.5	
	60 min feed	1.5	4.2		3.1	27.5	
	After feed						
	5 min	2			3.9		
	10 min	3.9			4.08	18.7	
	15 min	4.8			4.15		
	20 min	5.02	0.08	(21	4.2	10.2	0.86
	25 min	5.5			4.4		
	30 min	5.7	0.04	(14	4.6	7.3	0.67
	45 min	5.8			5.2	0.35	
	60 min	5.9	0.03		6.1	0.1	
Jul-04	Before feed	6.1	0.04	T = 30o(	6.2	0.03	T = 26oC
	5 min feed	3.6			3.1		
	10 min feed	3.1	1.6		2.7	1.9	
	15 min feed	2.8			2.5		
	20 min feed	2.7			1.8		
	30 min feed	2.5	11.5		1.7	10.2	
	40 min feed	2.7	16.5		1.6	11.4	
	60 min feed	3.01	24		1.5	18.7	
	After feed						
	5 min	3.4			2.1	13.9	
	10 min	3.6	18		2.25	10	
	15 min	3.6			2.5	5.8	0.86
	20 min	3.65	13.5	0 52	2.7	2.6	0.81
	25 min	3.7			3.25	0.53	
	30 min	3.75	10.1	0 16	4.4	0.2	0.62
	40 min	3.95	4.7		5.5	0.15	
	50 min	4.35	0.62		5.55		
	60 min	5.7	0.13	0 19	5.65	0.1	0.31

TABLE F 1

SUMMARY OF BIOKINETIC S MEASUREMENTS

Date	Measurement time		Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH 3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Jul-05	Before feed	pH	5.9	1.6	T = 30o	6.1	0.04	T = 25oC
	5 min feed		5.8			3.5		
	10 min feed		5.25	12		2.6		
	15 min feed		5.3			2.2	8.8	
water ->	20 min feed	x	5.5	17		2.3		
	30 min feed					2.35	15.5	
	40 min feed					2.15	20	
	60 min feed		5.3	24		2.3	24	
	After feed							
	5 min		5.3					
	10 min		5.3			3.3	13	1.1
	15 min		5.3	21.4	C 17	3.5		
	20 min		5.3			3.6	5.3	0.93
	25 min		5.5			4.2		
	30 min		5.6	15.2	C 29	4.5	1.4	0.75
	40 min		5.5			5.9	0.14	
	50 min		5.6			6.02		
	60 min		5.8	9.6	0 24	6.05	0.08	0.4
	90 min		5.8	6.4				
Jul-08	Before feed		5.9	2.3	T = 30oC	6.02	0.17	T = 25oC
	5 min feed		5.3			3.8		
	10 min feed		5.3			2.9		
	15 min feed		5.3	7.4		2.8	7.2	
	20 min feed		5.3			2.75		
	30 min feed		5.2	15.2		2.8	10.3	
	40 min feed		5.3			2.7		
	60 min feed		5.2	23.9		2.8	14	
	After feed							
	5 min		5.3			3.25		
	10 min		5.3			3.25		
	15 min		5.3	23	0 16	3.25	5.8	0.55
	20 min		5.5			3.5		
	25 min		5.6			3.8		
	30 min		5.5	21	0. 19	4.6	0.65	0.45
	40 min		5.6			5.7		
	50 min		5.8			5.85	0.3	
	60 min		5.8	18	0.1 98	5.9	0.2	0.23
Jul-10	Before feed		6.2	0.78	T = 30oC	6.05	0.17	T = 25oC
	5 min feed		5.55			4.9		
	10 min feed		5.38			3.2		
	15 min feed		5.35	7.4		2.9	3.8	
	20 min feed		5.34			2.9		
	30 min feed		5.3	15.2		2.8	6.2	
	45 min feed		5.2	23		2.7		
	60 min feed		5.2	31		2.75	14	
	After feed							
	5 min		5.25			3.25		
	10 min		5.3			3.3		
	15 min		5.4	30	0.(56	3.3	5.8	0.54
	20 min		5.4			3.6		
	25 min		5.5			3.8		
	30 min		5.5	29	0.(56	4.65	0.3	0.46
	45 min		5.6	26	0. 1	5.7	0.25	0.305
	50 min		5.6			5.8		
	60 min		5.7	24	0.1 16	5.9	0.2	0.23

TABLE :1

SUMMARY OF BIOKINET :S MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	ate (C -Ct)/t [mg N 13-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Jul-12	Before feed	6.2	0.22	T = 30 2	6.1	0.12	T = 24.5oC
	5 min feed	5.5			4.9		
	10 min feed	5.4			3.2		
	15 min feed	5.3	3.1		2.9	2.9	
	20 min feed	5.3			2.8		
	30 min feed	5.3	6.3		2.7	7.2	
	45 min feed	5.25			2.8		
	60 min feed	5.25	9		2.8	14.3	
	After feed						
	5 min	5.5			3.3		
	10 min	5.45			3.32		
	15 min	5.4	8	.066	3.5	7.4	0.46
	20 min	5.3			3.6		
	25 min	5.3			3.7		
	30 min	5.4	6	3.1	4.1	1.5	0.43
	45 min	5.45	5	088	5.9	0.32	0.31
	50 min				5.95		
	60 min	5.45	3.2	096	6.05	0.26	0.23
Jul-15	Before feed	6.1	0.2	T = 30c H	6.2	0.3	T = 24.5oC
	5 min feed	5.1			4.8		
	10 min feed	4.6			3.3		
	15 min feed	4.3	4.2		2.9	7.4	
	20 min feed	4.3			2.8		
	30 min feed	4.3	7.8		2.7	22	
	45 min feed	4.3	12.9		2.5		
	60 min feed	4.2	16.5		2.3	28	
	After feed						
	5 min	4.33			2.8		
	10 min	4.6			3.15		
	15 min	4.95	13.4	.2	3.35	21.2	0.45
	20 min	5			3.35		
	25 min	5.1			3.35		
	30 min	5	11	18	3.4	15.2	0.43
	45 min	5	9.1	164	3.6	9.4	0.41
	50 min	5			4.08		
	60 min	4.9	7.6	15	4.4	3.6	0.41
	90min	4.95	3.8	14	5.9	0.2	0.31
Jul-17	Before feed	6.1	0.09	T = 30o	6.2	0.08	T = 25oC
	5 min feed	5.5			5.1		
	10 min feed	4.55			4.2		
	15 min feed	4.3			3.3		
	20 min feed	4.2			2.8		
	30 min feed	4.15			2.7		
	45 min feed	4.1			2.6		
	60 min feed	4.15	17.5		2.5	41	
	After feed						
	5 min	4.3			2.5		
	10 min	4.6			2.5		
	15 min	4.7			2.5		
	20 min	4.75			2.6		
	25 min	4.8			2.6		
	30 min	4.8			2.7		
	45 min	4.8			3.2		
	50 min	4.9			3.5		
	60 min	4.95	7.2	17	3.6	7.1	0.56
	90min	5.2			4.8		

TABLE .1

SUMMARY OF BIOKINETI 'S MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	ate (C -Ct)/t [mg N '3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Jul-19	Before feed	6.1	0.08	T = 30c	6.05	0.07	T = 26oC
	5 min feed	4.9			5.2		
	10 min feed	4.5			3.9		
	15 min feed	3.9			3.3		
	20 min feed	3.8			2.8		
	30 min feed	3.7			2.7		
	45 min feed	3.65			2.6		
	60 min feed	3.6	23.2		2.5	33	
	After feed						
	5 min	3.9			3.3		
	10 min	4			3.4		
	15 min	4.05			3.4		
	20 min	4.05			3.4		
	25 min	4			3.2		
	30 min	4.1			3.3		
	45 min	4.15			3.4		
	50 min	4.2			3.4		
	60 min	4.2	5.6	29	3.9	6.7	0.44
	90min	4.8	1.3	24	5.1	0.22	0.36
Jul-22	Before feed	6.2	0.06	T = 30o	6.3	0.04	T = 26oC
	5 min feed	3.9			4.2		
	10 min feed	3.1			3.4		
	15 min feed	2.2			2.8		
	20 min feed	2.2			2.8		
	30 min feed	2.2			2.8		
	45 min feed	2.2			2.8		
	60 min feed	2.2	20.2		2.9	37.4	
	After feed						
	5 min	3.1			3.3		
	10 min	3.2			3.4		
	15 min	3.2			3.3		
	20 min	3.2			3.4		
	25 min	3.2			3.3		
	30 min	3.15			3.3		
	45 min	3.2			3.4		
	50 min	3.2			3.4		
	60 min	3.2	6.8	(22	3.9	10.8	0.44
	90min	3.4	1.4	(21	5.1	0.45	0.41
Jul-24	Before feed	6.4	0.03	T = 30o(	6.8	0.05	T = 25.5oC
	5 min feed	3.9			4.2		
	10 min feed	2.5			3.1		
	15 min feed	2.3			2.6		
	20 min feed	2.2			2.6		
	30 min feed	2.2			2.6		
	45 min feed	2.2			2.7		
	60 min feed	2.2	20.8		2.7	31.5	
	After feed						
	5 min	2.4			3		
	10 min	2.9			3.4		
	15 min	3.3			3.45		
	20 min	3.3			3.7		
	25 min	3.3			3.8		
	30 min	3.3	6.6	0 17	3.9	12.2	0.64
	45 min	3.7			4.1		
	50 min	4.7			4.4		
	60 min	6.3	0.24	0 14	4.6	2	0.49
	90 min	6.4	0.09	0 13	6.9	0.15	0.35
Jul-26	Before feed	6.6	0.03	T = 30o(	6.8	0.04	T = 25.0oC
	5 min feed	5.2			5.4		
	10 min feed	3.2			4.1		
	15 min feed	1.9			3.9		
	20 min feed	1.9			3.8		
	30 min feed	1.9			3.8		

TABLE 5.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0-Ct)/t [mg NH3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0-Ct)/t [mg NH3-N/min]
	45 min feed	1.95			3.8		
	60 min feed	2	28.5		3.9	38.4	
	After feed						
	5 min	2.4			3.8		
	10 min	2.4			3.8		
	15 min	2.5			3.9		
	20 min	2.5			3.8		
	25 min	2.5			3.9		
	30 min	2.5	12.3	.54	3.9	22.6	0.53
	45 min	3.7			3.9		
	50 min	4.9			4.2		
	60 min	5.8	0.56	.465	4.5	7.6	0.51
	90 min	6.2	0.06	.316	5.2	0.46	0.42
Jul-29	Before feed	6.6	0.06	T = 30	6.3	0.04	T = 24.3oC
	5 min feed	4.3			5.2		
	10 min feed	2.95			3.9		
	15 min feed	1.9			3.6		
	20 min feed	1.9			3.6		
	30 min feed	1.9			3.6		
	45 min feed	2			3.6		
	60 min feed	2	30.5		3.7	43.6	
	After feed						
	5 min	2.3			3.9		
	10 min	2.3			3.9		
	15 min	2.3			3.9		
	20 min	2.3			3.9		
	25 min	2.3			3.9		
	30 min	2.5	17.9	.42	3.9	31.8	0.39
	45 min	2.6			3.9		
	50 min	2.9			3.9		
	60 min	3.4	0.66	.49	4.3	18.5	0.385
	90 min	5.9	0.08	.34	4.5	6.3	0.41
Aug-02	Before feed	6.8	0.06	T = 30c	6.5	0.05	T = 24.0oC
	5 min feed	4.7			6.1		
	10 min feed	3.1			5.2		
	15 min feed	2.5			4.8		
	20 min feed	2.4			4.6		
	30 min feed	2.2	11.5		4.5		
	45 min feed	2.3			4.5		
	60 min feed	2.4	29.1		4.55	43.6	
	After feed						
	5 min	2.6			4.6		
	10 min	2.7			4.9		
	15 min	3	8.6	36	5		
	20 min	3.15			5.1		
	25 min	3.2			5.2		
	30 min	3.5	2	.9	5.2	27.5	0.54
	45 min	5.7			5.3		
	50 min	6.2			5.3		
	60 min	6.3	0.09	48	5.4	14.1	0.49
	90 min	6.4			5.6	2.5	0.46

TABLE F.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Aug-05	Before feed	6.6	0.04	T = 30oC	6.7	0.05	T = 23.5oC
	5 min feed	4.6			6.1		
	10 min feed	3.1			5.9		
	15 min feed	2.5			5.9		
	20 min feed	2.4			5.9		
	30 min feed	2.3	10.2		5.9	40.3	
	45 min feed	2.3			5.9		
	60 min feed	2.5	22		5.9	50.1	
	After feed						
	5 min	2.9			6.1		
	10 min	3			6.1		
	15 min	3.1	7.8	0.94	6.1		
	20 min	3.1			6.1		
	25 min	3.2			6.1		
	30 min	3.5	1.5	0.68	6.2	38.7	0.38
	45 min	4.8			6.3		
	50 min	5.6			6.3		
	60 min	6.1	0.08	0.36	6.4	27.7	0.37
	90 min	6.2			6.5	17.7	0.36
	120 min	6.3			6.5	8.9	0.34
Aug-07	Before feed	6.7	0.03	T = 30oC	7.2	0.04	T = 22.5oC
	5 min feed	4.5			6.5		
	10 min feed	2.9			5.7		
	15 min feed	2.5			4.9		
	20 min feed	2.5			4.2		
	30 min feed	2.4	7.8		4.3		
	45 min feed	2.5			4.2		
	60 min feed	2.6	14.9		4.2	44.3	
	After feed						
	5 min	2.7			4.3		
	10 min	2.9			4.5		
	15 min	3.2	7.8	0.47	4.7		
	20 min	3.3			4.9		
	25 min	3.4			5		
	30 min	3.5	1.1	1.46	5.1	32.8	0.38
	45 min	5.9	0.08	1.33	5.3		
	50 min	6.1			5.6		
	60 min	6.2			5.8	21.5	0.38
	90 min	6.3			6.05	14.4	0.33
	120 min	6.5			6.45	9.2	0.29
	180 min	6.7			7.1	1.2	0.24
Aug-12	Before feed	6.8	0.02	T = 30o	7.4	0.03	T = 21.5oC
	5 min feed	3.1					
	10 min feed	1.4			6.8		
	15 min feed	1.35			6.2		
	20 min feed	1.4			5.3		
	30 min feed	1.4	8.5		5.2		
	45 min feed	1.5			5.1		
	60 min feed	1.5	16.8		5.05	55.6	
	After feed						
	5 min	2.05			5.85		
	10 min	2.1			6.05		
	15 min	2.1	8.1	0.58	6.1		
	20 min	2.15			6.2		
	25 min	2.5			6.3		
	30 min	3.2	0.58	0.54	6.4	48	0.25
	45 min	6.4	0.09	0.37	6.4		
	50 min	6.4			6.4		
	60 min	6.5			6.4	41.1	0.24
	90 min	6.5			6.5		
	120 min				6.5	30.1	0.21
	180 min				6.5	17.6	0.21
	240 min				6.5	7.2	0.2

TABLE F.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Aug-14	Before feed	6.8	0.03	T = 30oC	7.9	0.03	T = 21.0oC
	5 min feed	3.3			7.1		
	10 min feed	1.6			6.2		
	15 min feed	1.4			5.5		
	20 min feed	1.4			5.5		
	30 min feed	1.4			5.5		
	45 min feed	1.5			5.6		
	60 min feed	1.6	16.4		5.7	58.4	
	After feed						
	5 min	2.15			5.9		
	10 min	2.2			6.05		
	15 min	2.2	7.9	0.56	6.1		
	20 min	2.25			6.1		
	25 min	2.5			6.05		
	30 min	3.1	0.52	0.53	6.1		
	45 min	6.3	0.08	0.36	6.1		
	50 min	6.4			6.1		
	60 min	6.5			6.2	48.3	0.16
	90 min	6.5			6.2		
	120 min				6.2	37.6	0.17
	180 min				6.3	19.4	0.21
	240 min				7.6	11.2	0.19
	300 min				8.15	0.06	0.19
Aug-19	Before feed	6.9	0.05	T = 29oC	8.2	0.08	T = 20.5oC
	5 min feed	3.5			7.3		
	10 min feed	1.2			6.3		
	15 min feed	1.2			5.4		
	20 min feed	1.3			5.4		
	30 min feed	1.3			5.4		
	45 min feed	1.4			5.4		
	60 min feed	1.6	19.3		5.4	61.9	
	After feed						
	5 min	1.7			5.35		
	10 min	1.8			5.4		
	15 min	1.8	8.6	0.71	5.4		
	20 min	1.9			5.3		
	25 min	2.2			5.4		
	30 min	3.1	0.16	0.64	5.4	56.9	0.16
	45 min	5.9			5.4		
	50 min	6.3			5.4		
	60 min	6.7	0.05	0.32	5.5	49.5	0.21
	90 min				5.6		
	120 min				5.8	38.6	0.19
	180 min				6.1	26.8	0.195
	240 min				6.9	15.2	0.19
	300 min				7.9	0.58	0.2

TABLE F.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Aug-23	Before feed	6.8	0.03	T = 29.5oC <- 10 mg/L FeCl3	8.1	0.05	T = 20.0oC
	5 min feed	3.8			6.9		
	10 min feed	1.9			5.3		
	15 min feed	1.8			4.1		
	20 min feed	1.8			3.9		
	30 min feed	1.8			3.9		
	45 min feed	1.8			3.9		
	60 min feed	1.9	14.8		4.1	54.3	
	After feed						
	5 min	1.9			4.1		
	10 min	2.1			4.1		
	15 min	2.2	5.1	0.64	4.1		
	20 min	2.4			4.1		
	25 min	4.2			4.1		
	30 min	5.1	0.18	0.49	4.1		
	45 min	6.1			4.1		
	50 min	6.2			4.1		
	60 min	6.3	0.06	0.24	4.1	37.9	0.27
	90 min	6.8			4.1		
	120 min				4.1	28.6	0.21
	180 min				4.3	18.2	0.2
	240 min				5.1	9.1	0.19
	300 min				6.9	0.36	0.18
Aug-25	Before feed	6.9	0.02	T = 30 oC <- 20 mg/L FeCl3	7.8	0.05	T = 19.0oC
	5 min feed	3.9			6.2		
	10 min feed	2.2			5.4		
	15 min feed	1.8			4.1		
	20 min feed	1.6			3.8		
	30 min feed	1.5			3.9		
	45 min feed	1.6			3.9		
	60 min feed	1.7	17.3		3.9	63.2	
	After feed						
	5 min	1.9			4.1		
	10 min	2.1			4.2		
	15 min	2.2	11.5	0.39	4.2		
	20 min	2.2			4.2		
	25 min	2.2			4.2		
	30 min	2.3	5.7	0.19	4.2		
	45 min	2.4			4.2		
	50 min	4.2			4.2		
	60 min	5.3	0.18	0.19	4.2	51.9	0.19
	90 min	6.5	0.06		4.2		
	120 min	6.8			4.2	42.3	0.17
	180 min				4.4	31.8	0.17
	240 min				4.3	21.3	0.17
	300 min				4.5	9.2	0.18
	360 min				6.8	0.12	0.18

TABLE F.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Aug-30	Before feed	6.8	0.03	*T = 29.5 oC* <- 30 mg/L FeCl3	7.9	0.06	*T = 25.5 oC*
	5 min feed	4.1			6.1		
	10 min feed	2.4			3.9		
	15 min feed	1.8			2.4		
	20 min feed	1.6			2.2		
	30 min feed	1.6			2.2		
	45 min feed	1.6			2.2		
	60 min feed	1.7	20.5		2.2	28.6	
	After feed						
	5 min	1.9			2.4		
	10 min	2.1			2.4		
	15 min	2.5	12.6	0.52	2.4		
	20 min	2.5			2.4		
	25 min	2.5			2.4		
	30 min	2.6	5.2	0.51	2.5	18.2	0.35
	45 min	3.2			2.6		
	50 min	4.8			2.7		
	60 min	5.1	0.22	0.34	2.8	9.2	0.32
	90 min	6.5	0.05		5.2	0.16	0.32
	120 min	6.8			7.2		
Sep-03	Before feed	6.7	0.02	*T = 29.5 oC* <- 40 mg/L FeCl3	6.9	0.02	*T = 30.5 oC* (4 L ML replaced)
	5 min feed	4.3			5.4		
	10 min feed	2.8			3.3		
	15 min feed	1.8			2.2		
	20 min feed	1.7			1.9		
	30 min feed	1.6			1.9		
	45 min feed	1.6			1.9		
	60 min feed	1.7	21.8		2.1	18.1	
	After feed				2.1		
	5 min	1.9			2.2		
	10 min	2.1			2.2		
	15 min	2.5	14.2	0.51	2.2	9.2	0.59
	20 min	2.5			2.2		
	25 min	2.5			2.2		
	30 min	2.6	6.1	0.52	2.6	0.22	0.59
	45 min	3.2			3.7		
	50 min	4.8			4.8		
	60 min	5.1	0.46	0.35	5.2	0.08	
	90 min	6.5	0.04		6.2		
	120 min	6.8					
Sep-06	Before feed	6.6	0.04	*T = 30.5 oC* <- 60 mg/L FeCl3	6.8	0.05	*T = 30.8 oC*
	5 min feed	4.6			4.9		
	10 min feed	3.1			3.3		
	15 min feed	1.8			2.3		
	20 min feed	1.7			2.1		
	30 min feed	1.6			1.9		
	45 min feed	1.8			1.9		
	60 min feed	1.6	25.6		1.9	35.7	
	After feed						
	5 min	1.9			1.9		
	10 min	2.1			2		
	15 min	2.2	17.5	0.54	2.1	25.2	0.7
	20 min	2.2			2		
	25 min	2.2			2		
	30 min	2.2	9.2	0.54	2.1	14.7	0.7
	45 min	2.6			2.2	4.3	0.69
	50 min	5.8			3.1		
	60 min	6.3	0.12	0.42	4.4	0.24	0.59
	90 min	6.4			6.3		

TABLE F.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
Sep-09	Before feed	6.5	0.03	T = 30.2 oC <- 70 mg/L FeCl3	6.6	0.02	T = 30.4 oC <- 30 mg/L FeCl3
	5 min feed	4.7			4.3		
	10 min feed	3.3			3.1		
	15 min feed	1.9			2.2		
	20 min feed	1.7			1.8		
	30 min feed	1.7			1.9		
	45 min feed	1.8			1.9		
	60 min feed	1.6	25.9		1.9	34.3	
	After feed						
	5 min	1.9			2.1		
	10 min	2			2		
	15 min	2.1	18.4	0.5	2.1	25.4	0.59
	20 min	2.2			2.2		
	25 min	2.2			2.2		
	30 min	2.2	10.2	0.52	2.1	15.6	0.62
	45 min	2.6			2.3	4.9	0.65
	50 min	5.8			3.2		
	60 min	6.3	0.16	0.43	4.6	0.26	0.56
	90 min	6.4	0.05	0.29	6.3		
Sep-13	Before feed	6.7	0.04	T = 25.5 oC <- 40 mg/L FeCl3	7.1	0.06	T = 28.5 oC <- 40 mg/L FeCl3
	5 min feed	4.9			5.7		
	10 min feed	3.6			3.7		
	15 min feed	2.2			2.2		
	20 min feed	2.2			1.8		
	30 min feed	2.2			1.9		
	45 min feed	2.2			1.9		
	60 min feed	2.2	29.2		1.9	25.2	
	After feed						
	5 min	2.8			2.1		
	10 min	2.8			2		
	15 min	2.8			2.1	17.3	0.52
	20 min	2.8			2.2		
	25 min	3.2			2.2		
	30 min	3.8	20.1	0.3	2.1	8.2	0.56
	45 min	3.8			2.3	0.26	0.55
	50 min	3.8			3.2		
	60 min	3.9	5.8	0.39	4.6	0.06	0.42
	90 min	5.7	0.26	0.32	6.3		
Sep-17	Before feed	6.8	0.03	T = 22.5 oC <- 40 mg/L FeCl3	6.8	0.04	T = 24.5 oC <- 40 mg/L FeCl3
	5 min feed	5.1		(3 L ML replaced	5.5		
	10 min feed	4.2		with water)	3.7		
	15 min feed	3.2			2.8		
	20 min feed	2.9			2.3		
	30 min feed	2.9			2.2		
	45 min feed	2.9			2.2		
	60 min feed	2.9	25.6		2.2	23.8	
	After feed						
	5 min	3.2			2.5		
	10 min	3.3			2.6		
	15 min	3.7	20.4	0.35	2.7		
	20 min	3.7			2.7		
	25 min	3.7			2.7		
	30 min	3.8	13.8	0.39	2.7	11.6	0.41
	45 min	3.9			3.2		
	50 min	3.9			3.3		
	60 min	3.9	4.8	0.28	3.4	0.38	0.42
	90 min	4.8	0.33	0.28	5.9	0.08	

TABLE F.1

SUMMARY OF BIOKINETICS MEASUREMENTS

Date	*Measurement time*	*Reactor # 1*		*Rate (C0 -Ct)/t [mg NH3-N/min]*	*Reactor # 2*		*Rate (C0 -Ct)/t [mg NH3-N/min]*
		DO (mgO2/L)	*NH3-N (mg/L)*		*DO (mgO2/L)*	*NH3-N (mg/L)*	
Sep-20	Before feed	6.9	0.05	*T = 23.5 oC* <- 40 mg/L FeCl3	7.1	0.04	*T = 22.5 oC* <- 40 mg/L FeCl3
	5 min feed	5.3		(3 L ML replaced	5.6		(500 ml ML
	10 min feed	4.5		with water)	3.9		replaced with water)
	15 min feed	3.2			2.8		
	20 min feed	2.4			2.4		
	30 min feed	2.1			2.2		
	45 min feed	2.2			2.1		
	60 min feed	2.2	20.6		2.1	23.8	
	After feed						
	5 min	2.4			2.3		
	10 min	2.4			2.3		
	15 min	2.4	14.4	**0.41**	2.3	17.1	**0.45**
	20 min	2.5			2.3		
	25 min	2.5			2.3		
	30 min	3.2	7.8	**0.43**	2.4	8.6	**0.5**
	45 min	3.7			2.9		
	50 min	3.9			3.3		
	60 min	4.8	0.18	**0.34**	3.7	0.12	**0.39**
	90 min	6.2	0.06		6.1	0.05	

TABLE F.2

SUMMARY OF BIOKINETICS MEASUREMENTS
DURING FINAL STAGE OF TREATABILITY STUDY

Date	*Measurement time*	*Reactor # 1*		*Rate*	*Reactor # 2*		*Rate*
		DO (mgO2/L)	*NH3-N (mg/L)*	*(C0 -Ct)/t [mg NH3-N/min]*	*DO (mgO2/L)*	*NH3-N (mg/L)*	*(C0 -Ct)/t [mg NH3-N/min]*
Oct-06	Before feed	6.8	0.05	*T = 30.2 oC* <- 40 mg/L FeCl3	7.2	0.04	*T = 22.5 oC* <- 40 mg/L FeCl3
	5 min feed	5.3			5.6		
	10 min feed	4.5			3.9		
	15 min feed	3.2			2.8		
	20 min feed	2.4			2.4		
	30 min feed	2.1			2.2		
	45 min feed	2.2			2.1		
	60 min feed	2.2	32.8		2.1	33.9	
	After feed						
	5 min	2.4			2.3		
	10 min	2.4			2.3		
	15 min	2.4	24.5	0.55	2.3	28.1	0.39
	20 min	2.5			2.3		
	25 min	2.5			2.3		
	30 min	3.2	18.3	0.48	2.4	22.3	0.39
	45 min	3.7			2.9		
	50 min	3.9			3.3		
	60 min	4.8	6.2	0.44	3.7	9.1	0.41
	90 min	6.2	0.06		6.1	0.13	
	HRT changed to 4 days				**Feed without aeration**		
Oct-07	Before feed	6.7	0.04	*T = 30.1 oC* <- 40 mg/L FeCl3	6.9	0.05	*T = 22.3 oC* <- 40 mg/L FeCl3
	5 min feed	5.1			4.2		
	10 min feed	4.2			3.6		
	15 min feed	2.9	7.1		3.2		
	20 min feed	2.4			1.8		
	30 min feed	2.2	13		0.43		
	45 min feed	1.9			0.31		
	60 min feed	1.8	29.8		0.22	48.4	
	After feed						start aeration
	5 min	1.9			1.7		
	10 min	2.1			2.6		
	15 min	2.1	25.9	0.26	5.2	50.9	
	20 min	2.2			5.04		
	25 min	2.2			4.01		
	30 min	2.2	22.5	0.24	2.9	42.2	0.58
	45 min	2.3			1.8	35.2	0.52
	50 min	2.3			1.8		
	60 min	2.3	15.3	0.24	1.8	29.3	0.36
	90 min	2.3	8.2	0.24	1.8	15.2	0.39
	120 min	2.4	1.9	0.23	1.8	5.6	0.37
	150 min	5.9	0.05		4.9	0.12	
	HRT changed to 3.5 days						
Oct-09	Before feed	6.9	0.06	*T = 30.4 oC* <- 40 mg/L FeCl3	7.7	0.04	*T = 22.6 oC* <- 40 mg/L FeCl3
	5 min feed	4.9			6.1		
	10 min feed	3.5			2.3		
	15 min feed	2.8			0.08	6.6	
	20 min feed	2.4			0.06		
	30 min feed	2.2	5.7		0.05	16.5	
	45 min feed	2.1			0.04		
	60 min feed	2.2			0.04	35.2	
	75 min feed	2.2	10.8				
	After feed						start aeration
	5 min	2.1			2.7		
	10 min	2.1			3.8		
	15 min	2.3	3.1	0.51	3.9	30.4	0.32
	20 min	2.6			2.6		
	25 min	2.9			2.2		
	30 min	3.6	0.23	0.35	1.8	26.2	0.3
	45 min	5.1			2.3	18.6	0.37
	50 min	6.2			2.8		

TABLE F.2

SUMMARY OF BIOKINETICS MEASUREMENTS
DURING FINAL STAGE OF TREATABILITY STUDY

Date	Measurement time	Reactor # 1 DO (mgO2/L)	Reactor # 1 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]	Reactor # 2 DO (mgO2/L)	Reactor # 2 NH3-N (mg/L)	Rate (C0 -Ct)/t [mg NH3-N/min]
	60 min	6.3	0.05		3.4	11.4	**0.39**
	90 min	6.4			3.8	1.9	**0.37**
	120 min	6.6			5.7	0.06	
	HRT changed to 3 days						
Oct-10	Before feed	6.8	0.04	*T = 30.1 oC* <- 40 mg/L FeCl3	7.6	0.05	*T = 22.2 oC* <- 40 mg/L FeCl3
	5 min feed	4.8			6.1		
	10 min feed	3.6			2.3		
	15 min feed	2.8			0.08		
	20 min feed	2.4			0.06		
	30 min feed	2.3			0.05		
	45 min feed	2.3			0.04		
	60 min feed	2.3			0.03	32.3	
	90 min feed	2.45	12.7				
	After feed						start aeration
	5 min	2.5			2.5		
	10 min	2.6			3.6		
	15 min	3.1	6.5	**0.41**	3.9	24.2	**0.54**
	20 min	3.3			2.7		
	25 min	4.2			2.2		
	30 min	5.2	0.82	**0.4**	2.3	15.9	**0.54**
	45 min	6.1	0.06		2.2		
	50 min	6.2			2.8		
	60 min	6.3			6.6	0.58	**0.52**
	90 min	6.5			6.8		
Oct-11	Before feed	6.9	0.05	*T = 27.3 oC* <- 40 mg/L FeCl3	7.5	0.03	*T = 22.3 oC* <- 40 mg/L FeCl3
	5 min feed	4.6			5.9		
	10 min feed	3.5			2.1		
	15 min feed	2.6			0.09		
	20 min feed	2.4			0.06		
	30 min feed	2.3			0.05		
	45 min feed	2.3			0.04		
	60 min feed	2.3			0.03	33.4	
	90 min feed	2.3	14.8				
	After feed						start aeration
	5 min	2.4			2.8		
	10 min	2.4			3.9		
	15 min	2.5	9.1	**0.38**	3.6	25.4	**0.53**
	20 min	2.5			2.6		
	25 min	2.8			2.2		
	30 min	3.8	2.8	**0.4**	2.3	17.1	**0.54**
	45 min	4.6			2.4		
	50 min	5.9			3.1		
	60 min	6.2	0.05		6.2	0.38	**0.55**
	90 min	6.3			6.8	0.06	
	Temperature gradually reduced				**HRT changed to 4 days HRT, feed without aeration**		
Oct-14	Before feed	7.6	0.03	T = 19.6 oC <- 40 mg/L FeCl3	8.1	0.03	*T = 19.3 oC* <- 40 mg/L FeCl3
	5 min feed	6.4			5.9		
	10 min feed	5.3			1.1		
	15 min feed	4.9	3.2		0.09	3.8	
	20 min feed	4.7			0.07		
	30 min feed	4.6	7.2		0.06	12.2	
	45 min feed	4.6	12.8		0.05	23.6	
	60 min feed	4.6	17.5		0.04	31.2	
	75 min feed	4.6	21.2		0.03	40.3	
	90 min feed	4.6	27.6				
	After feed						start aeration
	5 min	4.6			4.8		
	10 min	4.6			5.3		
	15 min	4.6	21.2	**0.42**	5.3	36.2	**0.27**
	20 min	4.6			5.1		

TABLE F.2

SUMMARY OF BIOKINETICS MEASUREMENTS
DURING FINAL STAGE OF TREATABILITY STUDY

Date	*Measurement time*	*Reactor # 1*		*Rate (C0 -Ct)/t [mg NH3-N/min]*	*Reactor # 2*		*Rate (C0 -Ct)/t [mg NH3-N/min]*
		DO (mgO2/L)	*NH3-N (mg/L)*		*DO (mgO2/L)*	*NH3-N (mg/L)*	
	25 min	4.6			5		
	30 min	4.7	17.6	0.33	4.8	31.7	0.29
	45 min	4.8	12.6	0.33	4.7	25.2	0.33
	50 min	4.9			4.75		
	60 min	5.2	7.4	0.33	4.8	18.5	0.36
	90 min	6.2	0.21		4.8	9.2	0.34
	120 min	6.6			4.9	1.9	0.32
	150 min	7.2			6.7	0.11	
Oct-16	Before feed	7.8	0.04	T = 19.3 oC <- 40 mg/L FeCl3	8.2	0.02	T = 19.1 oC <- 40 mg/L FeCl3
	5 min feed				5.8		
	10 min feed				1.2		
	15 min feed	5.2			0.09		
	20 min feed	4.9			0.07		
	30 min feed	4.7	7.8		0.06	12.8	
	45 min feed	4.6			0.06		
	60 min feed	4.5	17.6		0.05	31.6	
	75 min feed	4.6			0.04		
	90 min feed	4.6	29.5		0.03	40.9	
	After feed						start aeration
	5 min	4.7			3.9		
	10 min	4.9			4.8		
	15 min	5.05	25.7	0.25	5.3	36.9	0.26
	20 min	5			5.3		
	25 min	4.9			5.2		
	30 min	4.9	18.8	0.36	5.1	32.1	0.29
	45 min	4.9			5.1		
	50 min	4.9			4.8		
	60 min	4.9	9.5	0.33	4.5	25.7	0.25
	90 min	5.2	3.6	0.29	4.3	20.5	0.23
	120 min	6.8	0.16		4.6	11.6	0.24
	150 min	7.2			5.2	4.9	0.24
	180 min				6.6	0.42	

APPENDIX G

MICROTOX ANALYSES OF RAW GROUNDWATER AND EFFLUENTS AFTER UPSETS

TABLE G.1

RESULTS OF MICROTOX ANALYSES
WAUKEGAN NITRIFICATION STUDY
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Sample*	*Microtox Result*	*Comment*
Aug-08	Raw Mixture	2.30%	NH3-N = 720 mg/L
	After Feed	16.20%	NH3-N = 22.9 mg/L
	Effluent	100%	NH3-N = 0.06 mg/L
Sep-23	ML After Upset 1(no air)	100%	NH3-N = 76.2 mg/L
	ML After Washing	100%	NH3-N = 39.1 mg/L
	ML After RAS Exchange	100%	NH3-N = 30.4 mg/L
Sep-29	ML After Upset 2 (pH = 11.4)	14.60%	NH3-N = 46.3 mg/L
	ML After Washing	46.70%	NH3-N = 8.3 mg/L
	ML After RAS Exchange	100%	NH3-N = 2.8 mg/L

APPENDIX H

RESPIROMETRIC PROCEDURE AND CALCULATIONS

RESPIROMETRIC TESTS - GENERAL DESCRIPTION

Conestoga-Rovers and Associates (CRA) Treatability Laboratory is equipped with the respirometric system capable of carrying out a variety of biodegradation and biokinetic studies for aerobic and anaerobic systems. During Nitrification Study aerobic mode of the respirometer was used.

1.0 AEROBIC RESPIROMETRY

Aerobic respirometry allows simultaneous monitoring of biochemical oxygen demand in several reactors at a precisely controlled temperature. The reactors are fed with the same amount of biomass (RAS) but different concentrations of the investigated wastewater or the particular substance. This allows the determination of the biological activity of the investigated system in relation to the waste strength. On the basis of biological oxygen uptake data and the results of chemical analyses of reactor contents before and after the tests, biokinetic constants, namely maximum growth rate (μmax), sludge yield (Y), half rate concentrations (Ks and Ki) can be calculated. The biokinetic constants are then used to calculate the optimum design and operational parameters of biological treatment system for the investigated wastewater.

1.1 PRINCIPLE OF SYSTEM OPERATION

Respirometer monitors biochemical oxygen demand in closed reactor. As respiration takes place, oxygen is depleted and carbon dioxide is released at the same rate. Simultaneously, this carbon dioxide is removed from from the reactor atmosphere using solid potassium hydroxide. As a result, the pressure in the reactor drops. The Comput-OX system detects this drop in pressure and delivers oxygen to the reactor in measured increments. The system records the mass and volume of oxygen as well as the time it was delivered. It also generates numeric and graphic display for each test.

The Main Components of Respirometric System

Comput-OX, N-CON 12 channel respirometer:

- 12 reactors, each 1 L volume equipped with injecton/sampling ports;
- water bath with a precision temperature control; range: 5 - 35°C; precision of;
- temperature control: ± 0.1°C;
- PC, equipped with CTOX computer program for data collection; and
- instrument control.

APPENDIX I

ARSENIC MASS BALANCE IN SBR1

TABLE I.1

MASS BALANCE OF ARSENIC IN THE REACTOR SBR-1
BIOLOGICAL TREATMENT WITHOUT FERRIC CHLORIDE ADDITION
WAUKEGAN MANUFACTURED GAS AND COKE PLANT
WAUKEGAN, ILLINOIS

Date	*Arsenic conc (mg/L)*		*MLTSS*		*Sludge wasted (g/day)*	*Arsenic Accumulation*			*As in sludge (mg/g)*	
	Influent	*Effluent*	*(mg/L)*	*Total in reactor (g)*		*Load (mg/day)*	*Removal with sludge (mg/day)*	*Net (mg/15 L)*	*Calculated*	*Found*
2-Jun	6.4	1.4	10700	160.5	1.07	15	0.19	14.81	0.36	0.18
5-Jun	6.4	1.3	10600	159	1.06	15.3	0.19	15.11	0.70	0.32
9-Jun	6.4	2.2	10500	157.5	1.05	12.6	0.34	12.26	1.14	0.83
13-Jun	6.8	4.5	10400	156	1.04	6.9	0.86	6.04	1.15	0.96
17-Jun	6.8	5.7	10600	159	1.06	3.3	1.02	2.28	1.18	1.12
20-Jun	6.8	6.2	9800	147	0.89	1.8	1.00	0.80	1.21	1.19

CONESTOGA-ROVERS
& ASSOCIATES

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June 1, 2004

Reference No. 19023-99

Mr. Kevin Adler
United States Environmental Protection Agency
Region V
77 West Jackson Boulevard
Chicago, IL 60604-3590

Dear Mr. Adler:

Re: Nitrification Study
Waukegan Manufactured Gas and Coke Plant Site

We have enclosed a report on the "Nitrification Study" conducted on groundwater from the Waukegan Manufactured Gas and Coke Plant Site in Waukegan, Illinois. Copies of the report have been sent to Erin Rednour (IEPA) and Jewel Keiser (CH_2M Hill).

We will contact you within the next two weeks to schedule the "Status Meeting" to review the Nitrification Study results. In the interim, please contact us should any questions arise.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

for Alan W. Van Norman

AVN/cb/40
Encl.

c.c.: Rednour, Erin - IEPA (2 copies)
Keiser, Jewel - CH_2M Hill
Matuszak, Steve - Peoples Energy
Campbell, Jim - EMI
Armstrong, Stephen – McGuire Woods
Maynard, Jerome - Dykema-Gossett

[redacted]